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PREFACE

The 3rd International Technology Innovation and Industrial Management was organized in Oulu, Finland in 27.6. – 1.7.2011. The TIIM 2011 conference was jointly organized by the University of Oulu, the Oulu University of Applied Sciences and the Faculties of Engineering and Business Administration at Kasetsart University in Bangkok, Thailand.

The aim was that the TIIM 2011 brings together researchers, scholars, and practitioners from different countries from different parts of the world so that global viewpoints on technology, innovation and industrial management can be exchanged. The TIIM 2011 covered many topics. The scientific sessions were scheduled under titles: Organizational management perspectives, Decision-making and strategic management, Customer satisfaction, Knowledge management, Logistics, Productivity, Performance management, Sustainability, Well-being, Innovations in higher education, Product life-cycle management, Sourcing, Financial perspectives, Sustainability, Organizational learning and innovation, Business networks, Business process management and Trust in business relationships.

This proceeding is the collection of the 136 scientific papers accepted to be published and presented at the conference. They present many aspects of technology, innovation and industrial management. The papers are listed in the order of appearance in the conference itself. The editors wish that this publication was a useful tool for those participated in the TIIM 2011 conference and their co-authors to prepare new ideas for the TIIM 2012 in Lublin Poland. We also hope that some researchers outside the TIIM community find this edition useful with its very extensive scientific content.

We as the editors would like to express our sincere thanks to all authors and all those who made the TIIM 2011 a successful international academic event.

Editors
Hanna Kropsu-Vehkaperä
Aki Aapaoja
Tuomo Kinnunen
Pekka Kess

1st Parallel Sessions

Wednesday June 29, 2011
13:00 – 14:40

A1 – Customer Satisfaction

A1.1 **A study of precise marketing and customer information appraisal in collaborative enterprises**
Dr. Shangchia Liu

A1.2 **Modeling electronic word of mouth and complaint behavior for electronic CRM systems**
Conna Yang

A1.3 **A fuzzy hypothesis test based model for customer satisfaction measurement (Case Study in Pars Khodro Co.)**
Naimeh Borjalilu

A1.4 **A pilot survey to understand the effects technology readiness, satisfaction and electronic word-of-mouth on behavioral intention in online shopping environment**
Huei-Haung Chei

A1.5 **TQM and QFD approach to achieve customer satisfaction: A flour milling company case study**
Maqsood Sandhu

A STUDY OF PRECISE MARKETING AND CUSTOMER INFORMATION APPRAISAL IN COLLABORATIVE ENTERPRISES

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ABSTRACT

This study proposed an innovative and feasible Precise Marketing Model (PMM) which applies information sharing, collaborative marketing and data mining concepts to improve marketing efficiency and increase marketing performance. The purpose of this study is to develop the Precise Marketing Model prototype, which can assist small and medium sized enterprises (SMEs) locate new customers who match the 'significant few customer' profile according to the Pareto Principle and relocate 'the long tail' customers to other SMEs, in order to obtain the most favorable customers with greatest benefits.

This study adopted literature review, NGT and case study to develop the PMM operation mechanisms. There are six operating mechanisms of the PMM include collaborative regulations, user friendly operation system, co-marketing channel, information security, performance evaluation and attractive promotion activities.

This research will establish the PMM system prototype and validate the practical feasibility of the prototype by conducting three experimental studies and evaluating the performance of the prototype which are using. In the end, the study will discussed the implications for applying the CISM and suggested some directions for further study.

Keywords: precise marketing, collaboration commerce, database marketing, customer profiling

INTRODUCTION

Pareto Principle pointed out the concept of “trivial many and significant few”. 80% of the customers belong to “trivial many”. Without these customers, the company will be subjected to profit loss. But if the company lose a portion of the remaining 20% of the customers, the “significant few” group, the company will also be in trouble. How to keep the existing old customers and further develop the new customers belonging to “significant few” is becoming one of the most important strategies in business development.

Ulrich and Brockbank (2005) suggested customer literacy. Customer Literacy means that the business should clearly understand which customers are the significant few customers that bring in 80% of the company’s profit. The primary data, purchasing motives, purchasing habits and consumption behaviors of the customers are the customer literacy data that businesses should obtain and master. Information technology is quite a trend nowadays. Using it as a customer relationship management technique, not only can promote the interaction between the business and its customers, it can also help collect customer information from their interaction. By analyzing the marketing activities information like customer response, marketing and product supply relating statistical data, selling and purchasing data, customer data, customer online registration data, relating service data, product market data and internet selling data, businesses can clearly obtain the customer literacy of the significant few customers (Cachon and Lariviere, 2005). With clear customer literacy, the businesses can select different effective marketing strategies aimed for the significant few customers. In addition, businesses can undergo new customer development in target markets that conform to the customer literacy conditions and expect that the most efficient marketing strategy can help the company obtain the most profitable customers.

By leaning on marketing agent to obtain effective customer information is one of the fast methods for businesses to obtain effective customer information. In the recent years, due to the rapid development of information technology and internet, it is already very common to find both local and foreign companies through marketing agent to share their customer’s information. The credit card departments of many banks also use co-branded cards and inter-industry alliance to share each other’s customer database. For example, the credit card departments of banks and shopping malls use co-branded cards. Using the discounts and premiums to promote the consumption of the credit card users bring more business to shopping malls and the customers of shopping malls that apply for co-branded cards can obtain discounts and various services. The more important thing is that strategic alliance can combine both of their customer groups and the customers can also obtain more benefits and quality services. These examples of inter-industry alliance that shares customer information were already numerous (Weng et al., 2007).

Marketing agent need to establish customer relationship management system to all collaborative members in order to collect transaction information then use data mining to establish customer profile regulations. Then, add collaborative marketing to select and examine each other’s customer database. Lastly, through the marketing agent to integrated marketing platform to exchange the market information, marketing process and customer information.

LITERATURE REVIEW

There are important issues involved in the study: collaborative commerce, Transaction cost theory, and Social capital theory. The studies related to these issues will be reviewed in the section.

Corporate collaboration

Corporate collaboration allows organizations to improve the efficiency and quality of their business activities. It may occurs a workflow collaboration, a supply chain collaboration, or as collaborative commerce. Collaborative commerce uses information technology to achieve a closer integration and better management of business relationships between internal and external parties. There are many emerging issues in collaborative commerce and one of them is access control.

To implement collaborative commerce, interfaces between the system elements of the organizations that are involved in the collaboration are needed. However, access control policies are often inconsistent from interface to interface, and therefore conflict resolution should be considered to resolve multilevel access control policy problems. Many studies propose different rules for the resolution of the conflict between access control policies, but little attention has been given to the relationship between the groups or subject classes that represent the different types of corporate collaboration. In this paper, the format of corporate collaboration is considered, and the conflicts between the access control policies of interfaces are addressed. Some general guidelines, other than those that relate to minimum privilege on duty and maximum privilege on sharing, are proposed.

Transaction costs

Transaction costs arise because complete contracting is often impossible, and incomplete contracts give rise to subsequent renegotiations when the balance of power between the transacting parties shifts (Williamson, 1975). Five attributes of business exchange are positively associated with transaction costs:
(1) The necessity of investments in durable, specific assets;
(2) Infrequency of transacting;
(3) Task complexity and uncertainty;
(4) Difficulty in measuring task performance; and
(5) Interdependencies with other transactions.

The necessity of early investments in durable, transactions-specific assets (e.g. human and physical capital) shifts the balance of power between transaction participants, because in later renegotiations these costs are sunk costs of the party that incurs them. Infrequent transactions increase the likelihood of opportunistic behavior in later periods by reducing the threat of retribution. In situations where broader market reputations are at stake, infrequent transactions may be sustainable. However, even long-term contracts often do not provide sufficient adaptation mechanisms, and inflexibility may actually induce holdup. The five transaction attributes indicate settings in which opportunistic behavior is likely. If

transactions costs offset production cost advantages of the external supplier, the firm subsumes the activity an outcome termed vertical integration or in-sourcing.

Drawing on transaction cost economics theory, the sourcing decision is often seen as a rational decision made by firms that have considered transaction related factors such as asset specificity, environmental uncertainty, and other types of transaction costs. Whenever an activity is conducted under conditions of high uncertainty, or whenever an activity requires specific assets, transaction costs, the costs of writing, monitoring and enforcing contracts, are likely to be high. When transaction costs are high, outsourcing is deemed to be relatively inefficient compared with internal, hierarchical administration.

Social exchange theory

Social exchange theory was initially developed to examine interpersonal exchanges that are not purely economic. Several sociologists are responsible for the early development of this theory. These theorists view people's social behavior in terms of exchanges of resources. The need for social exchange is created by the scarcity of resources, prompting actors to engage one another to obtain valuable inputs. Social exchange can be defined as voluntary actions of individuals that are motivated by return they are expected to bring and typically in fact bring from others. Social exchange can be viewed as an ongoing reciprocal process in which actions are contingent on rewarding reactions from others (Das and Teng, 2002).

An exchange perspective places the study of international relations, such as global outsourcing, in a framework of negotiations. Central to this perspective are issues of equivalence (fairness) and contingency (responsiveness). The challenge for international actors is to define a precise medium for exchange. The more precise the medium, the less likely actors will misperceive one another's move. But, the more precise the medium the less likely will actors explore their relationships (Anderson, 2006). This is also a dilemma for IT outsourcing relationships. The more precise, the easier it is to follow-up service levels. And thus, value-added benefits will be difficult to achieve.

PRECISE MARKETING MODEL

Zha and Ding (2005) pointed out that information sharing is mostly used in the supply chain management of businesses. Most of the researches discussed the supply chain management of the information sharing among manufacturer, supplier and retailer. The shared information is mostly limited to the sales and inventory information to be used for the supply chain of the manufacturer and supplier. Besides, very few studies discussed the willingness of businesses to share information. In the analysis of Liu et al. (2006), the following were the main reasons: 1. The definition of information exchange model is unclear, 2. The distrust of the information exchange subjects, 3. There are some open questions in the information exchange contents, 4. How to evaluate the benefit of information exchange and 5. Internet privacy related responsibilities.

If the information exchange model can be applied to people exchange information in a virtual knowledge community, then, can this model also be applied to the inter-industry

alliance businesses that also share information? For example, gourmet restaurants and businesses under automobile industry can be of inter-industry alliance. The “trivial many” customers under the customer database of the gourmet restaurants might not be of much help for them but these customer information might be the valuable customers that conforms to the “significant few” customer conditions of the automobile company. Because the automobile company is familiar with the customer literacy of their own “significant few” customers, the customers that was originally to be abandoned by the gourmet restaurant might be the jewel that the automobile company are looking for. Once the automobile company has control over the new customer information provided by the gourmet restaurant and because these customers conform to the customer literacy of their significant few customers, they can immediately understand the needs and demands of their new customers and provide the best or most appropriate service for them. Similarly, the automobile company can also provide customer information that conforms to the significant few customers conditions of the gourmet restaurant. Not only have both of the businesses obtained the needed customer information, they also don’t need to use all the customer information in the customer database of the other party that cause ineffective and wasteful resources.

Although the case of the above-mentioned hypothesis seemed to be applicable, very few local or foreign studies focused on this topic. This study proposed the topic, “Why don’t we share?” for discussion. What are the reasons why inter-industry alliance businesses do not want to share their information? What are the factors considered by the inter-industry alliance companies when they undergo collaborative marketing? Which factors will influence the intention of the inter-industry alliance companies in exchange customer information? What are the barriers of marketing agent? What are the key success factors of marketing agent under collaborative marketing? This study hoped that the problems above can be answers after looking at the different angles in the discussion.

Developing new customers is always the one and only way of sustainability for businesses. How to accurately develop the “significant few” in Pareto Principle is the dream of every business top management. For large-scale businesses, with the use of customer relationship management and data mining, the customer profile of “significant few” customers can be obtained. Then use the strategic alliance model between the companies to collect or exchange customer data from the customer database of their alliance partner that conforms to the customer profile conditions. By using this model, the businesses can focus on a specific target market using customer segmentation method to satisfy every customer’s needs and accurately and efficiently develop new customers (Xu et al., 2002).

To be able to establish an innovative precise marketing model, the initial step of this study is to understand the framework, exchange method, exchange willingness and customer exchange critical factors of the present collaborative marketing information exchange. After collecting literatures on collaborative marketing, customer relationship management, data mining and exchange of customer information, design a conceptual framework of the precise marketing model under collaborative marketing. The framework and major components of the new model is illustrated. The framework can be illustrated as Figure 1.

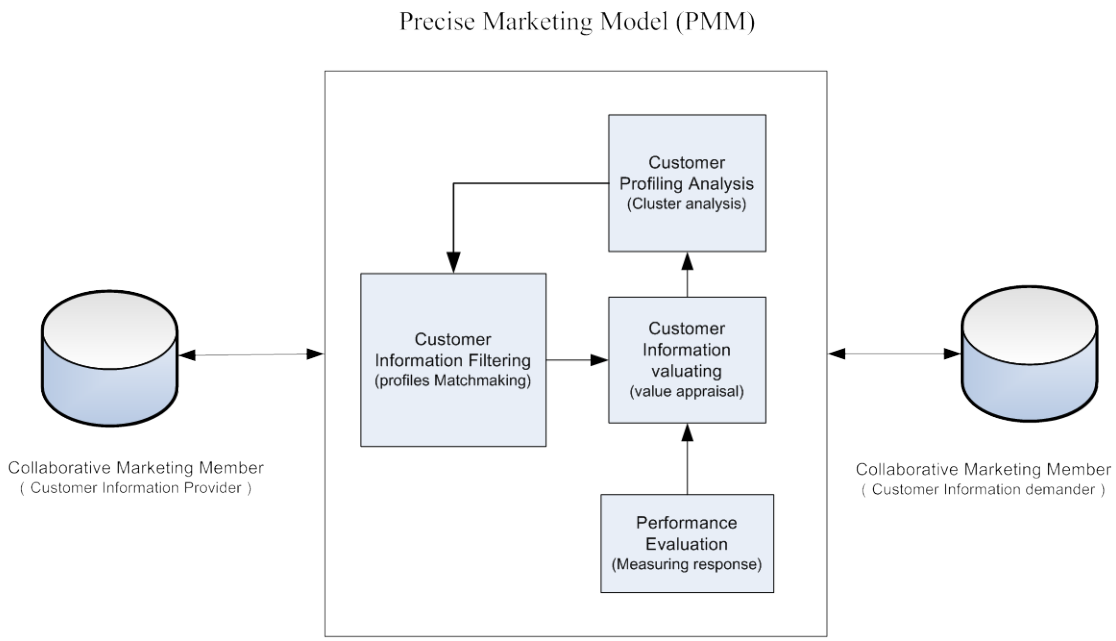

Figure 1: the Precise marketing model.

CONCLUSIONS

This study proposes a new precise marketing model to help enterprises developing new customers from each other. This model provides eight components for the collaborative marketing members: the integrated portal website with the personalized technology, the technical support for websites, the operations system, the integrated marketing and advertisement, the integrated management information system, the communication and control system, the education and training system, and the CRM system. Implementation strategies of the model are also proposed. These strategies are developed with respect to dimensions of operations, technology, and marketing, so that they can help the model be successfully implemented.

To implement the new model, several things should be noted. First, the proposed strategies should be appropriately executed. These strategies can help solve common problems of customer database sharing. Next, sufficient capabilities of the marketing agent and members are extremely important to implement the new model successfully. Third, to attract appropriate collaborative enterprises joining in the marketing agent is also quite crucial to the operation of the system. Providing sufficient assistance and support for these target enterprises according to their requirements will have a positive effect on the promotion of the marketing agent to potential members. Fourth, there may have some conflicts between the marketing agent and its members since the latter will lose a certain degree of autonomy due to regulations of the contract. Preparing some strategies of conflict management is therefore necessary to implement the new model smoothly.

This study builds up a new precise marketing model. The model is practically feasible and can be adapted to collaborative enterprises. In addition, the results of this study can also be used as the basis for the future study on database marketing or customer sharing models.

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MODELING ELECTRONIC WORD OF MOUTH AND COMPLAINT BEHAVIOR FOR ELECTRONIC CRM SYSTEMS

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ABSTRACT

Word of mouth is one of the quickest and most efficient ways to increase a product's awareness among consumers. Nowadays, people access to the Internet as a ubiquitous channel for information and experience sharing. In addition to traditional word of mouth, electronic word of mouth is an extremely important issue due to the heavy use of the Internet in modern society. This research studies the use of electronic word of mouth due to willingness to communicate and individual trust. Furthermore, tie strength is used as a construct to measure the interaction with electronic word of mouth. The SPSS statistical analysis software was used to analyze the data retrieved. The research results supports the hypothesis of a significant relationship between trust and willingness to communicate (F(1,169) = 3.984, p = 0.048). In addition, willingness to communicate, electronic word of mouth activity, and positive electronic word of mouth also have significant relationships. The results support the proposition that willingness to communicate serves as a mediator between trust and electronic word of mouth. The implications of these results for CRM systems are presented as a strategic summary.

Keywords: Electronic Word of Mouth, Electronic CRM Systems, Trust, Willingness to Communicate

RESEARCH BACKGROUND

The Internet provides a means of communication that substitutes traditional ways of promoting products, brands, and services. Through Word of Mouth (WOM) communication, passing information and shared experience is well known as an efficient way of spreading commercial messages. Bone (1995) notes that there is a growing research interest in measuring and influencing WOM effects since, "pre-usage attitudes about a product can be influenced by WOM communications," WOM effects have grown in importance with the emergence of the Internet [3]. This research evaluates Internet based sources of WOM communications and proposes a study to measure and influence WOM commercial communications. Varying among different industries, the strength of WOM is hypothesized

to influence the purchase intentions of consumers. The Internet provides a platform for electronic word of mouth. In comparison to traditional word of mouth where the information is passed on from person to person, electronic word of mouth is spread among a larger network of people where the geological distance and time barriers are eliminated. This study analyzes the interaction between interpersonal trust, willingness to communicate, and the tie strength among individuals. The research examines whether or not willingness to communicate is the mediator between trust and electronic word of mouth. If this is shown to be true, than the implications for the construction and altering of CRM systems are indicated.

Word of mouth communications which exist across different cultures and countries enables information flow between people. Word of Mouth is still one of most familiar means by which people spread and gain information on certain issues and topics and is defined as "informal communication directed at other consumers about the characteristics, ownership, or their sellers [24]." WOM is thought to be an outcome of customer experiences with a product or services [5]. Both positive and negative Word of Mouth can influence consumer decision making. A disappointed customer's reactions can be categorized into three different actions. The consumer might break the relationship, complain to others, or make their dissatisfaction known to the suppliers or company [15]. Out of these three, complaining to others, which is known in the literature as "negative WOM," has the greatest impact on a company's reputation and sales. Consumer purchase intentions lead to the search of shared experience which influences the outcome of purchase and complaint behavior. According to earlier publications, individuals usually keep 10% of their emotional experiences, whether good or bad, to themselves; the majority of the experience will be shared through the sharing of conversation [9]. After acquiring word of mouth information, sometimes consumers may exclude their own opinions and private information and adopt attitudes and opinions given by others [10]. The word of mouth effect is stronger when consumers are faced with ambiguous information requiring immediate or delayed decisions [3]. The advice from friends, family, or other individuals with persuasive power serves as an important factor for consumer decision making. "Word of mouth communications (WOM) is an interpersonal communication in which none of the participants are marketing sources" [3]. Traditional word of mouth based on experience is passed on from opinion leaders on to others [13]. Word of mouth does not necessarily rely on opinion leaders to be transmitted since ordinary consumers can also generate word of mouth.

For this research, word of mouth uses three dimensions to model Internet based positive and negative word of mouth. These three constructs are seen as different aspects to a single and more generalized measurement of WOM that can be independently studied [12]. Word of mouth activity is the level of enthusiasm and detail of conversational content exchanged between consumers about products. The content and frequency of electronic word of mouth sharing influences whether individuals will choose according to their own preference, character, and other antecedents. Richins (1983) argued that people are more likely to

spread negative attitudes rather than positive attitudes. When dissatisfied or disappointed with a certain product, customers tend to reveal their experience to friends and advise them not to make the same purchase.

The traditional CRM has been taken into the next level known as e-CRM (electronic CRM) which integrates technologies of new channels such as the internet into the corporation's CRM strategy [21]. With the help of e-CRM, consumer complaints can be collected and responded to using retention orientation approach. An important motivational concept is to focus on a consumer's lifelong value and an important key is avoiding negative word of mouth circulating on the Internet [25]. Instead, these negative word of mouth should be viewed as a remedy to repairs the consumer's satisfaction and the consumer will not be lost. The behavior of electronic word of mouth and complaints should therefore be further examined to have a better understanding of how e-CRM systems should function.

New media platforms such as the Internet offer different ways to spread word of mouth. The Internet in particular is the main portal for electronic word of mouth and has greatly changed marketing communications. Similar to traditional word of mouth, electronic word of mouth has higher reliability for changing attitudes than other forms of marketing information and strategies on the web [2]. The Internet enables different choices for consumers to communicate including blogs, forums, and websites. The traditional spread of word of mouth is limited by barriers such as distance, time, and cost of disseminating information. The Internet enables consumers to share their opinions and experiences with a multitude of other consumers [14]. In addition, consumers form social communities and exchange opinions and share advice when the flow of content is free. Consumers gather shared experiences posted on websites to learn more about a product before making a purchase [7]. Electronic word of mouth not only benefits consumers, but is also a new tool for the advertising industry. Media providers freely interact with consumers and advertise through the Internet. Electronic word of mouth shortens the distance between consumers and corporations and enables companies to reach out to a larger target audience [16].

For traditional word of mouth, the source of information is more tangible and people communicate in person whereas for electronic word of mouth, there are more channels and formats for information communication. Weblogs, often called "blogs," are personal web pages that are frequently updated with new articles and include photos, music, and links to other Internet sites [20]. New forms of micro-blogging simplify functions and make it easier for users to share their status, post short messages, or upload pictures through mobile phones or the internet. The difference between traditional blogging and micro-blogging is that the later offers a faster way of sharing information by encouraging users to keep their posts short. In addition, instant messaging is a type of technology on the Web that allows users to send and receive short text based messages and check the status of their friends who are online and available [6].

Each person has different tendencies to speak, write, or communicate with other people. The willingness to communicate is a personality trait that underlies the communication process [17]. The tendency to avoid communication originated from Burgoon's 1976 research which was based on factors such as introversion, lack of communication competence, alienation, low self-esteem, and communication apprehension [4]. Mortenson, Arntson, and Lustig (1977) used this construct to further develop the construct "willingness to communicate" which measures predisposition towards verbal communication. McCroskey and Baer define this construct as "the intention to initiate communication when given the opportunity."

Trust defines whether one chooses to believe another person's words or advice. Therefore, trust can be used as a variable to model whether word of mouth is accepted by consumers or not. One of the classical definitions of trust is that it is "a generalized expectancy held by an individual that the word of another can be relied on [23]" When reliable information is consistently provided by others, our trust is strengthened. The willingness to share information and the expectancies underlying the communication are the foundation of trust. Schurr and Ozanne (1985) describe trust as "the belief that one party's word is reliable and that it will fulfill its obligation in an exchange." A feeling of fear for negative outcomes or loss may occur if there is no trust.

According to research done by Rempel, Holmes, and Zanna (1985), there are many definitions that define the features of trust. First, it is built upon past experience and a series of events that strengthen the feeling of trust. Second, dispositional characteristics are made towards the trustor, including attributes such as reliability, dependability, and predictability. The third conclusion is that one must be willing to be put at risk, whether it is the risk of being hurt, or loss of something either abstract or tangible. The last conclusion is that trust can be defined by the sense of security and confidence in the responses given and the intimacy and strength of the relationship.

This research focuses on a feature of trust called interpersonal trust, which is "the expectancy held by an individual or a party that the word, promise, verbal, promise, or written statement of another individual or party can be relied on" [22]. Interpersonal trust is chosen as one of the research constructs because different from the more general definition of trust and focuses on the interaction between two individuals.

The social relationship of individuals can be categorized according to the frequency of contact, and how well others are known and are defined as the "potency of a bond between members of a network [11]," or "tie strength." Strong tie sources are friends and family, whereas weak ties are acquaintances and strangers [8]. The influence of tie strength can affect consumer decision making, word of mouth, and intergroup interactions [19]. Word of mouth communication is a social behavior that includes the exchange of information between individuals. Past research shows that tie strength influences the flow of

information. According to past research, individuals who are strongly tied relationship have more opportunities to interact and share information. If the Internet is used for communication between people, then these individuals logically have weaker ties. On the contrary, a weakly tied relationship offers few chances for individuals to spread information. Thus, strong ties should lead to the positive spread of word of mouth information and vice versa.

METHODOLOGY

This research explores the interaction between electronic word of mouth, willingness, trust, and tie strength. Past research supports a relationship between these constructs. In Ben-Ner and Putterman's 2009 study on trust and communication, the results show that if one desires to establish a relationship, then individuals must take the communication process seriously. Thus, the depth of communication promotes trustworthy behaviors. Other researchers have shown the interaction between trust and communication in different fields of study. "Communication is critical to building a trusting relationship which will create stability [1]." However, few studies explore the relationship between the level of interpersonal trust, willingness to communicate, and the impact on CRM systems. Although the content of communication is not completely associated with personal privacy or other matters, it is reasonable to believe that the more one is willing to be exposed, the more willing they are to share information with others. Therefore this study proposes that interpersonal trust will have a positive effect on willingness to communicate.

Word of mouth is an initiative action where an individual chooses to express his opinions or share past experiences with others. Word of mouth is an action that depends on the individual's intention to communicate so an individual's willingness to communicate with another person should be positively related with it. Therefore "willingness to communicate" is used as the third construct in the research framework. The strength of social relationships between individuals, or "tie strength," relates to the way the Internet expands our social networks. Those that we communicate with on the Internet do not necessarily have strong ties with others. Granovetter's research in 1983 shows that individuals with strong ties would more often communicate with individuals that are similar to themselves. When exploring the interaction between tie strength and electronic word of mouth, Granovetter's research implies that there should be a negative relationship between tie strength and electronic word of mouth. We derive from this literature review ten hypotheses. Trust has a positive effect on willingness to communicate, electronic word of mouth has a positive effect on willingness to communicate and acts as the mediator between trust and eWOM. Finally, tie strength has a negative and significant effect on eWOM.

Hypothesis 1: Trust has a significant and positive relationship with an individual's willingness to communicate.

Hypothesis 2: Trust has a significant and positive relationship with an individual's electronic word of mouth.

Hypothesis 3: Willingness to communicate will mediate the relationship between trust and electronic word of mouth.

Hypothesis 4: An individual's willingness to communicate has a significant and positive relationship with an individual's electronic word of mouth.

Hypothesis 5: An individual's tie strength with another individual on the internet has a significant relationship with electronic word of mouth.

In this study, questionnaires were handed out in campus classrooms with the help of friends. All data was collected using paper-based questionnaires. Most items utilized a five-point Likert scale ranging from 1 to 5, with 1 being "strongly disagree" and 5 being "strongly agree." Willingness to communicate to others is a self-report scale which is scored by the participants themselves. All the original items were designed in English and then translated into Traditional Chinese by a native speaker who is fluent in both languages to ensure the content and meaning remained the same during the translation.

The official questionnaire is divided into 5 sections, electronic word of mouth, trust, willingness to communicate, tie strength, and demographic variables. Electronic word of mouth activities were measured using Churchill's word of mouth scale which was modified by Harrison-Walker in 2001. Positive electronic word of mouth was measured by 3 items from the loyalty scale and electronic negative word of mouth used the scale from Liu and McClure's research on cross-cultural customer complaint behavior study. To improve the efficiency and increase the unity of the questionnaire, scales were modified from 7 points to 5 points. Rotter's Interpersonal Trust scale, which was developed in 1967, was used in the study to measure trust. In 1985, McCroskey proposed a scale to measure willingness to communicate which is a personality-based trait like scale that is consistent across different receivers and different communication contexts. This scale has 20 items, with 8 items being filler items. The willingness to communicate scale includes four communication contexts and three different receivers. The study measured each individual's general willingness to communicate. Hansen's 1999 two item scale measured the closeness of a working relationship and frequency of contact and is used to the measure of tie strength.

RESEARCH RESULTS AND DATA ANALYSIS

A reliability analysis for the 4 different variables showed that each constructs' alpha was above 0.70. Electronic word of mouth activity reached a Cronbach α of 0.78, positive electronic word of mouth 0.78 and negative electronic word of mouth 0.81. The trust scale has a Cronbach α of 0.76, scoring much higher than the 2 pretests conducted. Furthermore,

the 12 items of willingness to communicate had an internal consistency of 0.81, while tie strength had the highest internal consistency with an alpha of 0.92.

Performing a Regression Analysis on the retrieved data, we conclude that the R-square for several models was quite low. Yet, the most crucial part of this study is established with the predictive power of trust on willingness to communicate passing the P-value standard of 0.05, ($F(1,169) = 3.984$, $p = 0.048$). The regression results for willingness to communicate on both electronic word of mouth activity and positive electronic word of mouth is highly significant with P-values of ($F(1,169)=10.643$, $p = 0.001$) and ($F(1,169) = 9.113$, $p = 0.003$). The predictive powers and relationships of tie strength on all three dimensions of Electronic Word of Mouth Activity are significant.

The results imply that the stronger the relationship between two individuals, the more likely they are to share their experiences of good product purchases. Also, the higher the degree of communication willingness, the more an individual will use positive word of mouth. Negative electronic word of mouth is the only dimension that does not have a significant relationship with willingness to communicate. Therefore, even if one is willing to communicate and trusts other individuals, this does not mean that they will share their negative experiences with others.

Tie strength has a positive and significant relationship with both positive and negative electronic word of mouth, yet the relationship is not supported by electronic word of mouth activity. Hypotheses 2 is rejected since there is no significant positive relationship between Trust and Electronic Word of Mouth. However, trust does have a significant relationship with willingness to communicate. This supports the argument that the higher the degree of interpersonal trust, then the more willing consumers are to communicate and talk with others.

STRATEGIC IMPLICATIONS FOR CRM SYSTEMS

This research provides several new insights on how corporations can use electronic word of mouth as part of their strategic CRM design to attract and hold consumers. One of the most important management steps in e-CRM is to be able to take the consumer's point of view instead of a marketer's [21]. If the corporation can take use of the consumer behavior and encourage consumers to give feedback on the products, the chances of stopping an unsatisfied consumer from switching brands will help increase the consumer's lifelong value to the company. The results point out that individuals in this study are more reluctant to share negative word of mouth online even when they have a high degree of interpersonal trust with the communicator. Corporations can learn how to increase the consumers trust towards the company so that consumers will be willing to interact.

Analyzing the common goals of CRM in Table 1, several conclusions related to this research

can be derived. Electronic word of mouth should not be generalized to a single target audience. Corporations should divide the consumers into groups by the consumer's level of tie strengths when managing CRM systems. Since some customers feel a lack of desire to share negative purchasing experiences, they should be encouraged by the corporation that any form of feedback on the product is welcome. Also, traditional word of mouth is important for marketing events and may be combined with these findings. Marketers can manipulate the level of trust between initial consumers so that they are more willing to discuss the company's products with other people.

Table 1: Common CRM Goals and Strategic Implications.

Common Goals	***Strategic Implications***
1. Adapt processes to satisfy specific customer preferences	**Enforce the level of consumer trust towards the company**
2. Preserve the value of customers, target profitable segments, and cultivate high-quality relationships to ensure customer loyalty	**Corporations should aim to encourage customer feedback through the boosting of willingness to communicate**
3. Customer segmentation is a core function of CRM and frequently uses geographical data, demographic data, and behavioral variables to group customers	**Not all unsatisfied customers choose to voice their complaints. These types of customers should be approached and encouraged to voice their opinions**
4. To analyze customer segments, customer preferences, and provide best case service models	**Consumers can be offered incentives for posting or blogging word of mouth via Internet. Potential consumers who have strong ties with these individuals will then be stimulated to learn more about the product**
5. To gain customer knowledge	**Through the building of trust and willingness to communicate, corporations can activate its consumers to share their purchase experiences and advice.**

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A FUZZY HYPOTHESIS TEST BASED MODEL FOR CUSTOMER SATISFACTION MEASUREMENT
(CASE STUDY IN PARS KHODRO CO.)

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ABSTRACT

The article proposes a model for customer satisfaction measuring, which is adapted to use in automobile industries. The proposed methodology evaluates the satisfaction level of a set of customers in different aspect of customer focus based on hypothesis values for utilizing the intuitive judgments and decision-making vagueness and diagnoses the satisfaction customers associated fields. This model also allows fully evaluates by analysis of all possible hypothesis cases. In the end, we implement our model in KHODRO CO. in IRAN and show the results. This research does asking the opinions of the experts through a number of questionnaires related to the L90 auto customers of PARS KHODRO CO. in 5 fields. Customers satisfaction of L90 auto in above fields attains among 81 hypothesis and conclude the following result:"product quality is good, financial problems is good, Total quality of services is good and Guarantee is medium then customer satisfaction is good'' This findings lead to get safeguarding strategy in product quality, financial problem, Total quality of services fields and improvement strategy in Guarantee approach. It permits to evaluate the validity of a service/manufacturing operation from the point of view of consumers. It leads to the real satisfaction level and specifies the foible, strength and improvement opportunity, which they are essential information in the strategic management and latest planning in a company The main advantages of this method are fully consider the qualitative form of customers' judgments through fuzzy theory and evaluate customers' satisfaction in different aspect of customer focus. Compare to the other researches, this approach presents more realistic results. Our study represents one of the first attempts at customer satisfaction measuring by fuzzy hypothesis testing. Finally, future research directions are provided.

Keywords: fuzzy hypothesis test; customer satisfaction analysis; subjective judgments

INTRODUCTION

Paper's introduction is in two parts as customer satisfaction models and fuzzy hypothesis testing. According to our knowledge and researches, there is not a method for customer satisfaction measuring based on fuzzy hypothesis testing approach.

Customer satisfaction models

Globalization and free trade carry on remodeling the business environment and expanding global competition. Customer satisfaction is a resume notion and show the actual state of satisfaction which can vary from person to person and product/service to product/service. Therefore, customer satisfaction should be determined and rendered into a number of quantifiable parameters [1]. Also Since, customer satisfaction index (CSI) have been widely developed in both theory and applications [2, 18, 4, 5], especially in the fields of marketing, education, medical treatment, guesthouse management ,therefore customer satisfaction has been one of the most frequently surveyed topics in literature. The work done by Berry et al. [6] between 1985 and 1988 delivered SERVQUAL (it is a service-quality scheme that has been incorporated into customer-satisfaction surveys [7]), supports the basis for the measurement of customer satisfaction with a service by using the gap between the customer's expectation of achievement and their perceived experience of achievement. In 1989, the first model of CSI was built by Swedish researchers [8]. The American customer satisfaction index (ASCI) was set up in 1994 [9]. Another well-known CSI was built by 11 countries of European Union in1999 [10, 11]. Some researchers introduce modified CSI for using in the different fields. Hsu (2008) proposes an index for online customer satisfaction, which was adapted from an American Customer Satisfaction Index (ACSI). It predicts customer loyalty and overall customer satisfaction via a way was similar to the average for the online retail industry in ACSI and The partial least square (PLS) method [12]. Customer satisfaction web-based don´t terminate in the above paper. Customer satisfaction measurement index system via mail service is designed by LIU et al. (2006) [13]. Some of researches also focused on the relationship between customer satisfaction and financial performance [14, 15, 16]. According to Grigoroudis et al. (2000), customer satisfaction information is analyzed based on a preference disaggregation model. Their tool (Software) is termed as TELOS that follows the principles of multicriteria analysis and uses subjective customers' judgments [17]. Therefore, they propose a model that called MUSA (Multicriteria Satisfaction Analysis). It is a preference disaggregation model following the principles of ordinal regression analysis. Same as their mentioned paper, MUSA model uses subjective customers' judgments, too [3]. The Research of Mihelis et al. (2001) are concerned with a model that is based on the principles of multicriteria analysis and preference disaggregation modeling and it is implemented in private bank sector. It determines critical service dimensions and the investigation to customer classes with distinctive preferences and expectations [19]. Jaime and Fonseca (2009) consider the latent

segment models (LSM) approach for evaluation of customer's service satisfaction that quantified through multiple indicators. They selected a three latent segment model that represents “The Very Satisfied”, “The Well Satisfied” and “Satisfaction Demanders” [20]. Since Zadeh introduces fuzzy set theory in 1965 [21], researchers intend to use it in their quests. For example, Xiaohonget et al. (2008) introduces new method for calculating the e-commerce customer satisfaction index (ECSI), using fuzzy techniques [22], so that ECSI obtains by fusion of comparison customers' cognition in e-commerce and their acclaims and complaints.

The purpose of our study is to utilize the fuzzy hypothesis testing for customer satisfaction measuring, such that, satisfaction level is caused by six fields as product quality ، financial problems ، total quality of services ، guarantee ، complaints and loyalty. The fuzzy hypothesis test is developed crisp hypothesis testing but it challenge the all possible hypotheses. In other hand, it utilizes ambiguity and vagueness of subjective judgments by fuzzy logic.

Fuzzy hypothesis testing

As discussed in previous section, main structure of our method is based on fuzzy hypothesis testing. In the real world, sometimes data cannot be recorded or collected precisely. Therefore, the fuzzy sets theory is naturally used as an appropriate tool in modeling the statistical models when the fuzzy data have been observed [23]. The concept of fuzzy sets used here was originally introduced in [21] and described in more detail e.g. in [24, 25]. It should be noted that in this paper only the hypotheses are allowed to be fuzzy and the data are assumed to remain crisp. Furthermore, the 'classical' way of statistical inference is generalized to fuzzy hypotheses. Note that there is a fundamental difference between a membership function of a linguistic term and a prior probability distribution. The membership function just gives a description of the linguistic term, whereas a prior probability distribution gives prior information about the truth of the hypotheses under consideration. Arnold [26, 27] proposed the fuzzification of usual statistical hypotheses and considered the hypotheses testing under fuzzy constraints on the type I and II errors. Casals and Gil [28] and Son et al. [29] considered the Neyman–Pearson type testing hypotheses. Saade [30, 31] considered the binary hypotheses testing and discussed the fuzzy likelihood functions in the decision making process by applying a fuzzified version of the Bayes criterion. Gil et al. [32] also discussed the likelihood ratio test for goodness of fit with fuzzy observations by means of the minimum inaccuracy principle of point estimation. Casals and Gil [33], Casals and Gil [34], and Gil et al. [35] considered the Bayesian sequential tests and χ^2 tests for goodness of fit with fuzzy observations by means of the notion of fuzzy information. Grzegorzewski [36], Watanabe and Imaizumi [37] proposed the fuzzy test for hypotheses testing with vague data, and the fuzzy test gave the acceptability of the null and alternative hypotheses. Niskanen [38] discussed the applications of soft statistical

hypotheses in the human sciences. The fuzzy hypothesis testing is developed of classic statistical hypothesis testing which zero and one are using for acceptance or rejection of any hypothesis. However, fuzzy hypothesis testing has two strength points versus classic statistical hypothesis testing. They are: (1) it considers all the possible hypotheses and (2) accepts them relatively by numbers in [0, 1].The fuzzy hypothesis testing – like the classic statistical hypothesis testing-has four steps: hypothesis formulation, sampling, hypothesis testing and decision-making. In hypothesis formulation step, all the possible hypotheses are formulated. Classical hypotheses define two type hypotheses as null hypothesis and alternative. However, fuzzy hypotheses formulated by a block consist of hard-core and associated auxiliary hypotheses. In the sampling step, a subset of all data is selected. The sample should has enough data to be a good indication of the all data. In hypothesis testing step, fuzzy conclusion for any hypothesis is done and then, results are aggregated by aggregation function. In final step, total result has to be analyzed and associated decisions are made.

The paper organization is according to the follows:
Section 2, describes information collection tools, its validity and reliability, and some information about case location. Section 3, is describes our methodology which is consist of fuzzy hypothesis concept, structure of our approach, model implementing and its finding. Finally the last section, conclude the models efficiency and results.

INFORMATION COLLECTIONS

Case Location and Sampling

Pars Khodro Company (P.K.C.) is an automobile manufacturer company that is established in 1956 and since then is operational. In P.K.C. the environment of the competitive markets changes intensely and it is necessary to improve the manufacturing quality continuously. Hence, we introduce a way to evaluate the P.K.C's manufacturing quality, which is based on the degree of user satisfaction. The statistical universe of this paper is considered from total customers of L90 (one of the Pars Khodro products started in 2009). In this paper, random systematic method for sampling is used [39] and due to list of total customers of L90 in 2009, Morgan table is utilized for numbers of samples [40] in which the best sample numbers corresponded to any universe cardinality. Accordingly, a sample of 380 from 20000 customers is considered as good representative of total data.

Tools

In this paper, main information collecting tool is questionnaires and interviews. Interview is used to analyze customers' viewpoints before questionnaire designing. Questionnaire also is

used to measure the satisfaction samples in framework of hypotheses. Initial questionnaire has six essential fields and each field has several sub-fields as follows:

1. Product quality
    1.1. Apparent form
    1.2. Safety
    1.3. Car body specifications
    1.4. Motor power and fuelling
    1.5. Good ventilation and power means
    1.6. Technical documents quality
2. Financial problems
    2.1. Cost of product
    2.2. Fair relation between cost and quality
    2.3. Purchase styles
    2.4. Financial operation rapidity
    2.5. Attention and clarity in financial affairs
3. Total quality of services
    3.1. Managers and experts communication manner
    3.2. Inform manner quality
    3.3. Delivery quality
    3.4. Guarantee conditions
4. Guarantee
    4.1. Provide the spare parts
    4.2. Parts ampleness and quality
    4.3. Guarantee access
    4.4. Repairs quality
    4.5. Guarantee cost and wage
5. Complaints
    5.1. Complaints receiving ways
    5.2. Complaints investigation quickness
    5.3. Complaints consideration
6. Loyalty
    6.1. Continuing cooperation
    6.2. Looking forward to the fresh products
    6.3. Suggest to other peoples

After the initial collection of 30 questionnaires and evaluation of feedbacks, we integrate them with experts' opinions. Accordingly, due to overlapping and concluded by another, loyalty eliminated from questionnaires and then, final questionnaire is formed. The Response of any question was set according to Likert scale [41], which scaled as: poor satisfaction, Medium poor satisfaction, Fair, medium good satisfaction and good satisfaction.

Validity and Reliability

The method of exploratory factor analysis has been used to analyze the questionnaire validity [39]. The KMO* value of questionnaire is 0.895 in 0.01 significant level which imply to sampling sufficiency for method of exploratory factor analysis. Varimax rotation was used for exploratory factor analysis, and result implies that: first factor (product quality) explains the 75% changes, second factor (financial problems) explains the 81% changes, third factor (Total quality of services) explains the 73% changes, Guarantee factor explains 74% changes and finally, complaints factor explains the 79% changes. Generally, the questionnaire forecast the 73% changes that indicate the validity. Of course, load factor of fields was greater than 0.5. The Cronbach's alpha method has been used to analyze the questionnaire reliability [42] which was calculated Cronbach's alpha for product quality , 75% ; financial problem , 79% ; Total quality of services , 72% ; Guarantee , 80% and complaints, 79%.This results indicates the reliability of customer satisfaction measurement scale. It is necessary to mention that the investigations have been done by MINITAB 15.0 software.

MATHEMATICAL FRAMEWORK OF FUZZY HYPOTHESIS TESTING

Fuzzy hypothesis test is extension of classical statistics hypothesis test. It leads to importance degree of each hypothesis compare with auxiliary rules. Let, X be universes of discourse ،$D = \{x_1 , x_2 , \dots , x_m\}$ be sample set and $H = \{H_1 , H_2 , \dots , H_n\}$ be if-then rule statements. In this view, we can demonstrate a fuzzy if-then rule as follows:
H_i: IF $\{Condition\ 1, Condition\ 2, \dots , Condition\ k\}$ to be considered true, THEN X is a member of F by membership degree(x).
Nevertheless, general structure of fuzzy hypothesis test is as Table 1:

Table 1: fuzzy hypothesis test matrix.

If-then statements	**Samples**				$\mathbf{M_L(D)}$
	x_1	x_2	$\cdots$	x_n	
$\mathbf{H_1}$					
$\mathbf{H_2}$					
$\vdots$					
$\mathbf{H_r}$					
					Summation=1

* Kaiser-Meyer-Olkin

It should be noted that, auxiliary rules are in $\{Condition\ 1, Condition\ 2, \ldots, Condition\ k\}$ and main hypothesis is included in F notation. The if-part of the rule is called the antecedent, while the then-part is called the consequent or conclusion. Each sample x_i satisfies $condition\ 1$, $condition\ 2$ through $conditionk$ within$\mu_1(x_i)$, $\mu_2(x_i)$ through$\mu_k(x_i)$, respectively. In other hand, x_i satisfies the consequent within $\mu(x)$ that is defined as:

$$\mu : (H, x) \rightarrow [0,1] \qquad (1)$$

Due to multiple parts related to the antecedent and consequent, apply fuzzy logic operators and resolve them to a single number between 0 and 1,therefore we apply multiplication operator (P.M. Larson relation) for combining the antecedent and consequent such as fuzzy logic operators. So, satisfaction degree of each hypothesis by x_i sample calculates by equation (2). Hence, attain associated array of jth row and ith column for Table (1).

$$Sat_{x_i}(H_j) = \mu_1(x_i) \times \mu_2(x_i) \times \ldots \times \mu_k(x_i) \times \mu(x_i) \qquad (2)$$

To determine the verification degree of each hypothesis (claim), so it is necessary to calculate all possible $Sat_{x_i}(H_j)$ $\forall i, j$ and then, find arithmetic mean as follows:

$$M_j(D) = \frac{\sum_{i=1}^{n} Sat_{x_i}(H_j)}{n} \quad j = 1,2, \ldots, r \qquad (3)$$

Fuzzy hypothesis testing in customer satisfaction measuring

In this section, we intend to introduce the set of hypotheses in our model. Claims $H = \{H_1, H_2, \ldots, H_n\}$have been introduced and are calculated verification degree of each ($\mu_k(x_i)$). As discussed in section 2.0, five fields are used in this model ; product quality, financial problems, Total quality of services, Guarantee are antecedents and then complaints is rule's consequent that implies to customer satisfaction level. We classify each of them in to the three scales as, good ، medium and bad. As an example, Total qualities of services investigate in the three classes; good Total quality، medium Total quality and bad Total quality. So, to analyze the total classifications of fields, we will have $3 \times 3 \times 3 \times 3 = 81$ hypothesis. All hypotheses have been analyzed in our paper. As an example, one of the hypothesis could be "product quality is good, financial problem is good, Total quality of services is bad, Guarantee is medium and then customer satisfaction level (complaints) is medium". The fuzzy classifications are as shown in Figure 1.

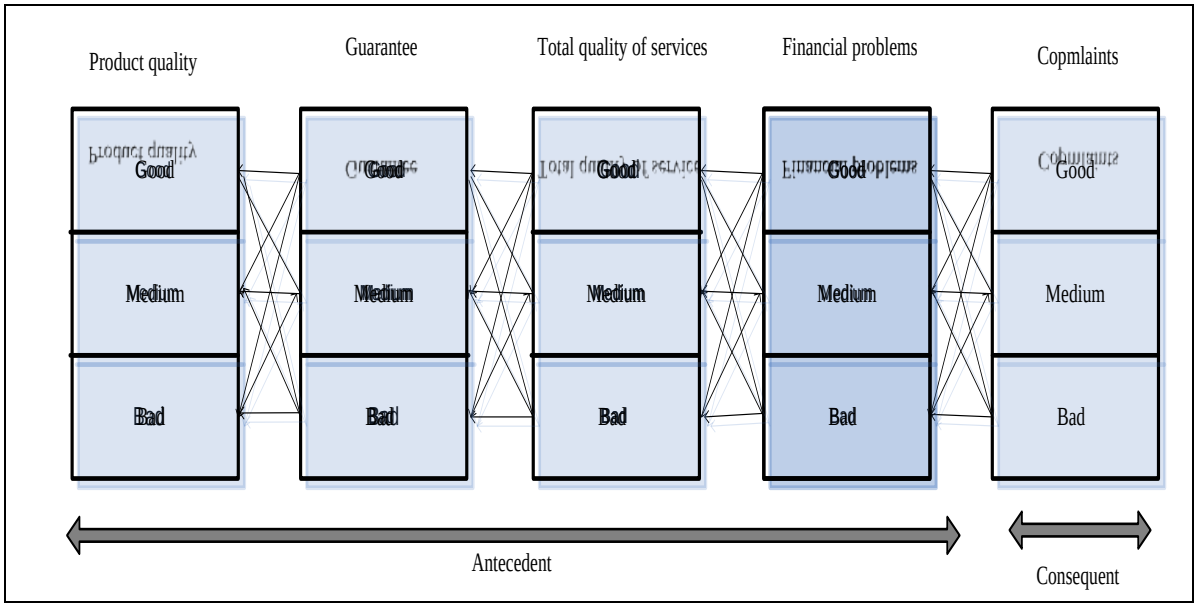


Figure 1: The fuzzy classification of case study variables.

As discussed in above, linguistic terms have been used in any classifications. Good ، medium and bad are our linguistic terms. So, accordingly we need to design theirs fuzzy distributions. Figure 2 demonstrate the linguistic values of any linguistic variable in which ranges have been got from interview with company experts. Note that, concept of "complaint" is negative, so, the more values imply to worse condition. Figure 3 demonstrate the linguistic terms that are based on the parameters which are different in each fields.

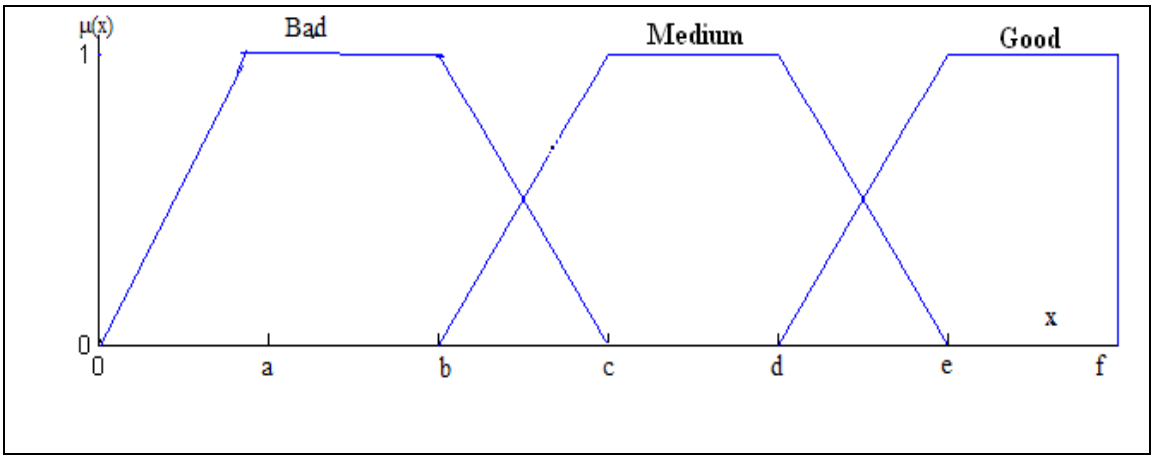


Figure 3: linguistic terms based on the parameters.

The parameters have been allotted as Figure 2.So, the membership functions of good, medium and bad linguistic terms are indicated as follows:

$$\mu_{good}(x) = \begin{cases} \frac{1}{e-d}(x-d) & x \in [d,e] \\ 1 & x \in [e,f] \end{cases} \qquad (4)$$

$$\mu_{\text{medium}}(x) = \begin{cases} \frac{1}{c-b}(x-b) & x \in [b,c] \\ 1 & x \in (c,d] \\ \frac{-1}{e-d}(x-d)+1 & x \in (d,e] \end{cases} \quad (5)$$

$$\mu_{\text{bad}}(x) = \begin{cases} \frac{1}{a}x & x \in [0,a] \\ 1 & x \in (a,b] \\ \frac{-1}{c-b}(x-c) & x \in (b,c] \end{cases} \quad (6)$$

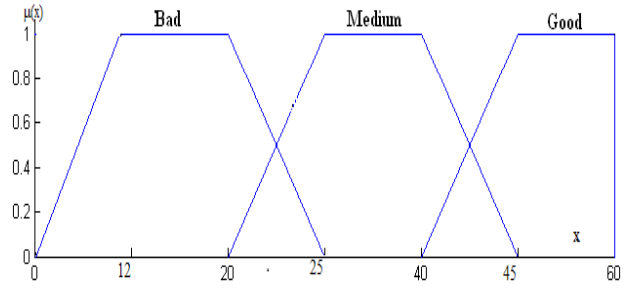
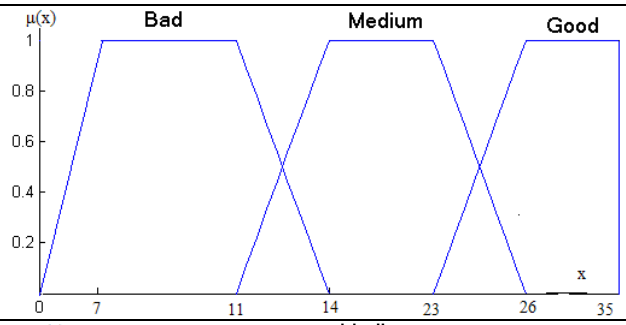
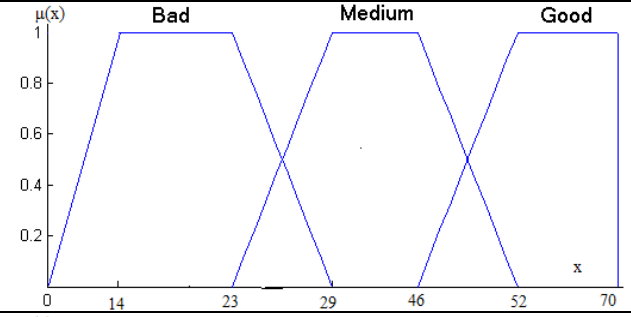
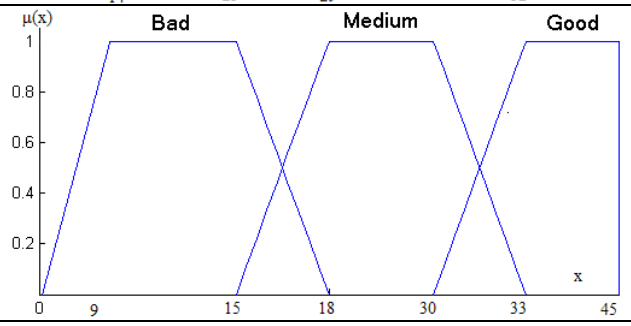
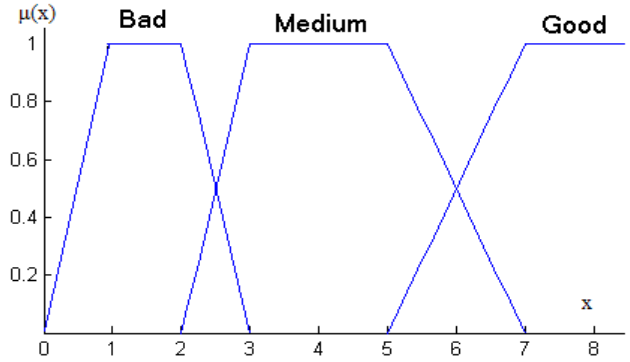
	Bad = (0,12,20,25) Medium=(20,25,40,45) Good=(40,45,60,60)	Product Quality
	Bad = (0,7,11,14) Medium=(11,14,23,26) Good=(23,26,35,35)	Financial problems
	Bad = (0,14,23,29) Medium=(23,29,46,52) Good=(46,52,70,70)	Total quality of service
	Bad = (0,9,15,18) Medium=(15,18,30,33) Good=(30,33,45,45)	Guarantee
	Good = (0,1,2,3) Medium=(2,3,5,7) Bad =(5,7,inf,inf)	Complaints

Figure 2: Distribution of good, medium and bad linguistic values.

In this stage, the verification degree of each claim has been calculated according to the customers´ data. As an example, let "product quality is medium, financial problems is good, total quality of services is medium, Guarantee is medium and customer satisfaction level is medium" for one of the customer (Due to Table 2). So, the verification degree for this customer is$0.8 \times 0.25 \times 0.14 \times 0.87 \times 1 = 0.02$. In a similar way, via each customer, the verification degree for other hypotheses has been calculated. This procedure repeats for other customers and the verification degree of each 81 hypothesis are calculated as described in section 3.0. Note that, customer i play role of x_i that is explained in section3.0. Table 2 depicts satisfaction degree of each linguistic variable by one of the $customer$.

Table 2: satisfaction degree of each linguistic variable by one of the customer.

Ling. variables	**Product quality**				**Financial problems**				**Total quality of services**				**Guarantee**				**Customer satisfaction level (Complaints)**			
Ling. values	G[1]	M[2]	B[3]	Score	G	M	B	Score	G	M	B	Score	G	M	B	Score	G	M	B	Score
Sat. degree	0.2	0.8	-	42	0.25	0.75	-	36	0.86	0.14	-	32	0.13	0.87	-	35	-	1	-	4

1. G: Good 2. M: Medium 3. B: Bad

Findings

The results of hypotheses testing have been introduced as $M_{H_1}, M_{H_2}, \dots, M_{H_{81}}$ which are verification degrees of $H_1, H_2, \dots, H_{81}$ hypotheses. If verification degrees of H_i be greater than other hypotheses, then, we can conclude that H_i accurance possibility is greater than others. As shown in Table 3, the top five highest verification degrees are shown and the hypothesis "product quality is good, financial problem is good, Total quality of services is good and Guarantee is medium and as a result, customer satisfaction is good'' has the highest verification degree among the others. So, we can say, this claim has the more conformances in company case. This findings lead to get safeguarding strategy in product quality, financial problem, Total quality of services fields and improvement strategy in Guarantee approach.

Table 3: The top five highest verification degrees of hypotheses for L90.

Priority	Hypothesis
1	product quality is good , financial problems is good, Total quality of services is good , Guarantee is medium and as a result, customer satisfaction is good
2	product quality is good , financial problems is good, Total quality of services is good , Guarantee is good and as a result, customer satisfaction is good
3	product quality is medium, financial problems is good, Total quality of services is medium , Guarantee is medium and as a result, customer satisfaction is medium
4	product quality is good , financial problems is medium, Total quality of services is medium , Guarantee is medium and as a result, customer satisfaction is medium
5	product quality is medium, financial problems is medium, Total quality of services is medium , Guarantee is bad and as a result, customer satisfaction is medium

CONCLUSIONS

Due to increase global competition, customer satisfaction should be determined and rendered into a number of quantifiable parameters. Accordingly, different methods have been introduced to customer satisfaction measurement. Nevertheless, none of them did not use vagueness of customers' judgments and did not probe comprehensively the varied satisfaction fields. The proposed method used the fuzzy hypothesis testing for utilizing the intuitive judgments and decision-making vagueness and diagnoses the satisfaction customers associated fields. It leads to the real satisfaction level and specifies the foible, strength and improvement opportunity, which they are essential information in the strategic management and latest planning in a company. This paper was implemented in Pars Khodro Co. and study L90 satisfaction customers in 2009. Finally, the result of this research emphasize on “product quality is good, financial problem is good, Total quality of services is good and Guarantee is medium then customer satisfaction is good’’ hypothesis. Compare to the other researches, this approach presents more realistic results. Due to diversity of I.K.C's products, it is proposed this paper's method applied on other products and obtained results be aggregated as total customer satisfaction index. For the more attention, next researches must focus on most affecting the customer satisfaction parameters and gather them by reliable approach and then results compare with other company in automobile industries.

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A PILOT SURVEY TO UNDERSTAND THE EFFECTS TECHNOLOGY READINESS, SATISFACTION AND ELECTRONIC WORD-OF-MOUTH ON BEHAVIORAL INTENTION IN ONLINE SHOPPING ENVIRONMENTS

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ABSTRACT

In this research, the effects of the electronic word-of-mouth in 3C products industry are investigated, and the suggestions to utilize the power of the electronic word-of-mouth more efficiently and effectively are also made. In order to target at all kinds of consumers, the technology readiness of consumers is also considered. Moreover, customer satisfaction and behavioral intention reflect the result of the electronic word-of-mouth. In order to understand the characteristics and the willingness to refer to the electronic word-of-mouth before consumers purchase 3C products, questionnaires are used to collect data for analysis.

The relationships between the four perceptions of technology readiness, the willingness to refer to the electronic word-of-mouth, customer satisfaction and behavioral intention are analyzed. According to the analysis results, five recommendations for 3C manufacturers are made. Firstly, 3C products manufacturers should cooperate with some online 3C products discussion forum. Secondly, 3C products manufacturers should always pay attention to customers' opinions and complaints on the Internet. Thirdly, 3C products manufacturers should make the instructions and information of their products easier to be understood. Fourthly, 3C products manufacturers should focus more on the opinion leaders on the Internet. Lastly, 3C products manufacturers should provide more advanced technical support to those pioneers of purchasing new products.

Keywords: electronic word-of-mouth, technology readiness, satisfaction, behavioral intention, online shopping

INTRODUCTION

Since the Internet technology was developed, the spread of information has been much faster than before. It is easier for people to search for information about all kinds of products on the Internet. Nowadays, more and more customers survey other consumers' experiences and opinions on products and services before purchasing something. Therefore, traditional advertisements, such as television advertisements, radio advertisements and newspaper advertisements, are not sufficient for companies to promote their products and services. Companies are forced to develop new strategies for Internet marketing.

However, due to the overload of advertisements every day, consumers do not have enough time to review each of them by themselves and are forced to ignore most of the advertisements. Instead, they usually prefer to gain opinions and experiences about products or services which they want to purchase from their friends, colleagues or families. This noncommercial information exchange is called word-of-mouth, and word-of-mouth plays a very important role in consumer behavior. It has an effect on consumers' decisions of long-term and short-term procurements (Bone, 1995). Furthermore, the Internet offers a fastest and most convenient channel for consumers to exchange information, so more and more people exchange their opinions and experiences about products and services on the Internet. Such exchanging behavior is regarded as the electronic word-of-mouth.

The rapid development of Internet technology has led the growth of computer relative industries which is called 3C (Computer, Communication and Consumer) industry. 3C industry has grown significantly for these twenty years, and most of the analysts agree that 3C industry will still occupy a significant position in the global market in the future. Nevertheless, 3C industry is highly competitive and has changed very fast. Manufacturers have to be highly sensitive to the market changes and the feedback from consumers.

Utilizing the electronic word-of-mouth is the most efficient approach to deliver information about new products to customers as well as gain the feedback from them. In order to promote new 3C products more effectively, 3C manufacturers have paid more and more attention to the electronic word-of-mouth. There are many professional online discussion forums which provide platforms for Internet users to share their experiences and opinions on 3C products, for example Mobile01 (www.mobile01.com) and My Mobile Life (www.mml.com.tw).

In spite of the fact that 3C manufacturers have noticed the importance of the electronic word-of-mouth, they still have much difficulty in utilizing the electronic word-or-mouth. For instance, the Internet users are anonymous and this makes it difficult for manufacturers to know if the information is delivered to their target customers. Thus, targeting at the right customers is important for manufacturers. Furthermore, although the development of Internet technology has fastened the spread of the electronic word-of-mouth, there are some customers who still do not have confidence to use new technologies.

In this research, the effects of the electronic word-of-mouth about 3C products are discussed. Customer satisfaction and behavioral intention represent that if consumers will purchase products again, recommend products to others and increase their loyalty of the 3C manufacturers. Therefore, consumers' satisfaction and behavioral intention directly affect 3C manufacturers' profit and market share. In view of this, one of the aims in this research is to find out if the electronic word-of-mouth does influence the customer satisfaction and behavioral intention when they purchase 3C products.

Furthermore, technology readiness index is used to measure customers' beliefs and feelings of adopting new technologies. Customers with different technology readiness may have different customer satisfaction and behavioral intention. Thus, another aim in this research is to make some suggestions for 3C manufacturers according to customers with different technology readiness.

Lastly, based on the analysis results, some recommendations of improving the effectiveness of the electronic word-of-mouth in 3C products industries are given.

LITERATURE REVIEW

Electronic word-of-mouth

Westbrook (1987) defines word-of-mouth as the opinion which consumers communicate to others in an unofficial way after they have used a product or taken a service. Bristor (1990) defines word-of-mouth as the approach to obtain others' experiences through the interaction of social network. Moreover, word-of-mouth is defined as all comments on a particular product or company within a certain time by Rosen (2001). This information communication is normally thought more neutral and more reliable, because it is mostly generated directly by consumers rather than by companies. Misner (2008) says that the word-of-mouth is "the world's best known marketing secret" and the most effective marketing strategy. Some people think that marketing is about advertisements and promotions. Engel, Blackwell and Miniard (2001) mentioned that the post-purchase behavior is reactions after consumers purchased a product. There are two types of reactions which are feeling satisfied and feeling dissatisfied.

The development of the Internet has promoted the growth of electronic word-of-mouth. Information and opinions are exchanged and spread by plenty different platforms such as emails, MSN messenger, BBS (Bulletin Board System), online discussion forums, message boards, newsgroup, industrial portal discussion area, chat room and so on. The traditional word-of-mouth is instantaneous and passed face to face, but the electronic word-of-mouth could be spread faster, in anytime, and in a way of one to many. Gelb and Johnson (1995) suggested that the information which is communicated via the Internet is a kind of word-of-mouth. Because the electronic word-of-mouth is not limited by time and distance, the electronic word-of-mouth is more effective, more convenient and broader. In physical world, if a customer feels dissatisfied, he/she may tell the other six people about his/her dissatisfaction. However, in the world of Internet, if a customer feels dissatisfied, his/her dissatisfaction can be delivered to more than six thousand people by Internet platforms. In some cases, this number may be underestimated (Wang, 2004). Therefore, even though the electronic word-of-mouth could not replace the traditional word-of-mouth, the electronic word-of-mouth has been thought as the most powerful potential marketing approach.

Litvin, Goldsmith and Pan (2008) mention challenges and opportunities of the electronic word-of-mouth, and Wang (2004) compares the difference between the electronic and the traditional word-of-mouth. The above discussions are summarized as below.

1. The electronic word-of-mouth is less restricted. The traditional word-of-mouth normally happens when two or a group of people meet in the same place at the same time. They talk face to face and discuss the same topic. However, when the information is exchanged on the Internet, it is not restricted by time, places and environments. The electronic word-of-mouth could even also be passed to people who don't know each other. This advantage accelerates the spread of electronic word-of-mouth.

2. The electronic word-of-mouth may sometimes be ignored. The traditional word-of-mouth is an interaction between the information transmitter and receiver. Because both parties are interested in the topic which they are discussing, the direct communication between each other helps to clarify questions and reduce the perceived risk more effectively. However, the electronic word-of-mouth is based on the Internet platforms, and sometimes it can't be interacted immediately. Therefore, the information transmitter could not be sure whether the receiver is interested in that issue, or the issue raised by the transmitter is clear enough or not. Consequently, the electronic word-of-mouth may be ignored as advertisements sometimes.

3. The electronic word-of-mouth contains multimedia information. The traditional word-of-mouth is mainly based on oral conversation and sometimes assisted by body languages. The electronic word-of-mouth can be communicated by multimedia such as words, photographs, images, sounds, 3D (three dimension) images, videos and so on. The various multimedia attracts more attention, and helps information receivers to understand the information more easily and more completely. Therefore, the electronic word-of-mouth provides richer and more diverse contents than the traditional one.

4. The electronic word-of-mouth could be spread out broader. Wang (2004) claims that the traditional word-of-mouth communicates as cell division which is one to one delivery. For example, the spread is started by one person, and every transmitter tells another person face to face at every stage. There will be 2^n persons receiving this message at the n^{th} stage. However, the spread of electronic word-of-mouth is broader, which is like nuclear reaction. For example, the information is posted on the Internet by one person, and every transmitter forwards this web link to m persons at every stage. There will be $\left(m^n - 1\right) / \left(m - 1\right)$ persons receiving this message at the n^{th} stage. By using the technology of the Internet, the electronic word-of-mouth could be spread more extensively and faster than the traditional one.

5. The electronic word-of-mouth is more cost effective. Nowadays, communications and information exchanges take place frequently in our workplace and daily life. However, comparing with the other communication approaches, face to face communication takes higher opportunity and time costs. Therefore, the occurring frequency of the traditional word-of-mouth is reduced. The Internet is used by most people everyday, and the cost is relatively low. Thus, the electronic word-of-mouth is more cost effective by using the Internet.

6. The electronic word-of-mouth may not be trusted. The traditional word-of-mouth is a kind of physical contact between people, and the face to face communication and interaction help people to build up trust and to reduce risks, which are the main purpose of searching for word-of-mouth. However, there are many fakes, lies, unreal advertisements on the Internet, and anonymity which is one of the properties of the Internet makes it hard for consumers to identify the reliability of the source of information (Fang and Chang, 2006). Thus, the electronic word-of-mouth is thought not as reliable as the traditional one, and may not be trusted sometimes.

7. The electronic word-of-mouth may generate new topics and ideas. Since the electronic word-of-mouth can be spread broader, there are more various Internet users participating in discussions. Because of the variety of Internet users and the extensive spread, they usually bring new ideas and information into discussions.

Nowadays, manufacturers and retailers promote and advertise their products and services by many different media such as newspapers, television programs, radios, Web sites and so on. However, how customers select a new product or service mainly depends on word-of-mouth. Rosen (2001) addresses three reasons explaining the significance of word-of-mouth. These three reasons are illustrated in the following.

1. "Customers are hardly hear you" (Rosen, 2001). The amount of information has grown sharply everyday. Since new technologies of media have been implemented, such as Internet and digital broadcasting, people receive various information everyday. For example, "a weekday edition of the New York Times contains more information than what an average person was likely to come cross in his/her lifetime in seventeenth-century England" (Richard Saul Wurman, cited in Rosen 2001). Some of the information is useful for receivers, but some is not. Therefore, information overload causes noises to customers. People are forced to ignore most of the information from these noises, and customers feel more comfortable to seek information from those people who they know.

2. "Customers are skeptical" (Rosen, 2001). According to the survey which is made by Porter Novelli co., there are only 37% people who think that information from software or computer companies are believable. If the information is from pharmacy companies, only 28% of the people consider the information believable. If the information is from vehicle manufacturers, only 18% of the people think the information believable. Moreover, if the information is from insurance companies, only 16% of the people think that it is believable (Rosen, 2001). It is difficult for customers to determine which information is real from those huge amounts of information. Besides, a lot of information is not real, and it results in unhappy purchase experience. Thus, customers are skeptical, and they would rather believe in word-of-mouth than advertisements.

3. "Customers are connected" (Rosen, 2001). Humans are a kind of animals who live in groups. Communication is human nature. Since the Internet has been well developed, communication has become easier for people to exchange information even with strangers or people who are in a different continent. Therefore, the opinions and information about a product are spread worldwide in a very short time, and it is very easy for consumers to get this word-of-mouth.

Technology readiness index

While adopting new technologies is easy for some people, it might be difficult for others. Parasuraman (2000) defines technology readiness index as "people's propensity to embrace and use new technologies for accomplishing goals in home life and work". Technology readiness can be seen as a psychological status. There are two kinds of forces in psychology affecting the willingness to use new technologies, which are enablers and inhibitors.

Parasuraman and Colby (2001) cooperated with Rockbridge Associates Inc. and interviewed customers of Rockbridge Associates Inc. with focus groups. After interviews, they summarized the positive and negative feelings about facing new technologies. According to this research, Parasuraman and Colby (2001) propose four dimensions of measuring technology readiness index, which are the optimism, innovativeness, discomfort and insecurity. These four dimensions are explained in the following.

1. The optimism represents positive views on new technologies, and it means that people feel more controllable, flexible and efficient when using new technologies. People who are optimistic about technology think that they have the ability to make good use of new technologies, and believe that new technologies can help them improve their life and work.
2. The innovativeness represents the intention to become a pioneer of technology and thought leader. People with the perception of the innovativeness feel like trying new technologies all the time.

3. The discomfort means the feelings of lack of control over new technologies. People with the perception of discomfort are not confident in using new technologies and are overwhelmed by using them.

4. The insecurity means the distrust of new technologies. People with the perception of insecurity doubt whether technology could work properly or not.

By using technology readiness index, it is clearer to understand customers' beliefs and feelings about adopting new technologies.

Customer satisfaction

Cardozo (1965) is the first person who discusses customer satisfaction in marketing area. He addresses that because the market has become so competitive, more and more companies have paid more attentions to customer satisfaction. Customer satisfaction has become a big issue in business governance. Customer satisfaction can affect consumers' intention to purchase the same products again or purchase other products.

Customer satisfaction can be discussed from two different angles: psychologically and economically. From customers' psychological point of view, if the purchase result is better than what a customer expects, the customer will feel satisfied. On the other hand, if the purchase result is worse than a customer's expectation, the customer will feel dissatisfied (Hampel, cited in Tsai 2005). From customers' economical viewpoint, if the benefit of the product or service is worthier than the time and money a consumer has invested, the consumer will feel satisfied. Otherwise, the consumer will be dissatisfied (Howard and Sheth, 1969). Oliver (1981) defines customer satisfaction as an emotional reaction which results from a purchase experience. Anderson, Fornell and Lehmann (1994) think that customer satisfaction is an overall accumulative evaluation of a company after consumers have experienced their products or services.

Kotler (2000) says that the cost on attracting a new customer is five times more than the cost on retaining an existing customer. Reichheld (1996) mentions that improving customer satisfaction helps enterprises to reduce their costs and increase their profits. What is more, it helps enterprises build and spread the positive word-of-mouth. According to Jones and Sasser (1995), those companies earning higher customer satisfaction perform better in profits and growth. Because of the higher customer satisfaction, customer loyalty and sales are also increased. Consequently, Lee (2006) addresses that customer satisfaction directly affects the reputation and the financial performance of a company.

To sum up the literatures mentioned above, customer satisfaction is an emotional reaction after consumers purchase and experience a product or service. These accumulative reactions have become the customer satisfaction with a company. The positive customer satisfaction results in the higher customer loyalty and the higher willingness to repurchase. Since customer relationship is a virtual asset of enterprise, higher customer satisfaction brings higher profits and higher market share for companies. Therefore, aiming high customer satisfaction is one of important goals for the majority of enterprises. Thus, in this research, we discuss how technology readiness index and the electronic word-of-mouth affect customer satisfaction.

Behavioral intention

Nowadays, the life cycle of products is shorter than before. A successful business relies on not only having good sales of products or services but also having a long term relationship with customers. Therefore, how to make consumers repurchase the products and build loyalties are more important than the promotion of single product or service. In order to understand if customers would buy products or services of the same company again, behavioral intention is used to forecast consumers' behavior.

Zeithaml, Berry and Parasuraman (1996) think that behavioral intention can be classified into two types which are the favorable and unfavorable intention. If consumers have the favorable intention towards a company, they would spread the positive word-of-mouth for the company, increase the loyalty to the company and increase the purchase amount of products or services of the company. On the other hand, if consumers have the unfavorable intention towards a company, they would reduce the purchase amount, spread the negative word-of-mouth and purchase other alternative products or services from other companies.

Zeithaml, Berry and Parasuraman (1996) measure behavioral intention in five dimensions. There are two dimensions related to the favorable intention, which are the loyalty and paying more. Chen (2002) mentions that behavioral intention is an important indicator which is used to understand if customers are going to remain in a company or defect from the company. Consequently, in this research, we discuss how technology readiness index, the electronic word-of-mouth and customer satisfaction influence behavioral intention.

RESEARCH METHODOLOGY

Research framework

In order to understand the relationships between technology readiness, the electronic word-of-mouth, customer satisfaction and behavioral intention, the research model is designed as Figure 1. According to Parasuraman and Colby (2001), technology readiness index can be measured in four dimensions which are the optimism, innovativeness, discomfort and insecurity. Relationships between these four dimensions and the electronic word-of-mouth, customer satisfaction and behavioral intention are also discussed respectively in this model.

Research method

There are two major research methods used in this research which are the qualitative and quantitative research method. The qualitative research method is used for the non-standardized data, the data which are expressed by words and conceptualized data. The quantitative research method is used for standardized data, the data which are represented by numbers or the statistic data (Saunders, Lewis and Thornhill, 2000). In this research, the statistic analysis is used to find out the relationships between variables, so the quantitative research method is used. Furthermore, the results of all measurement items are numerical.

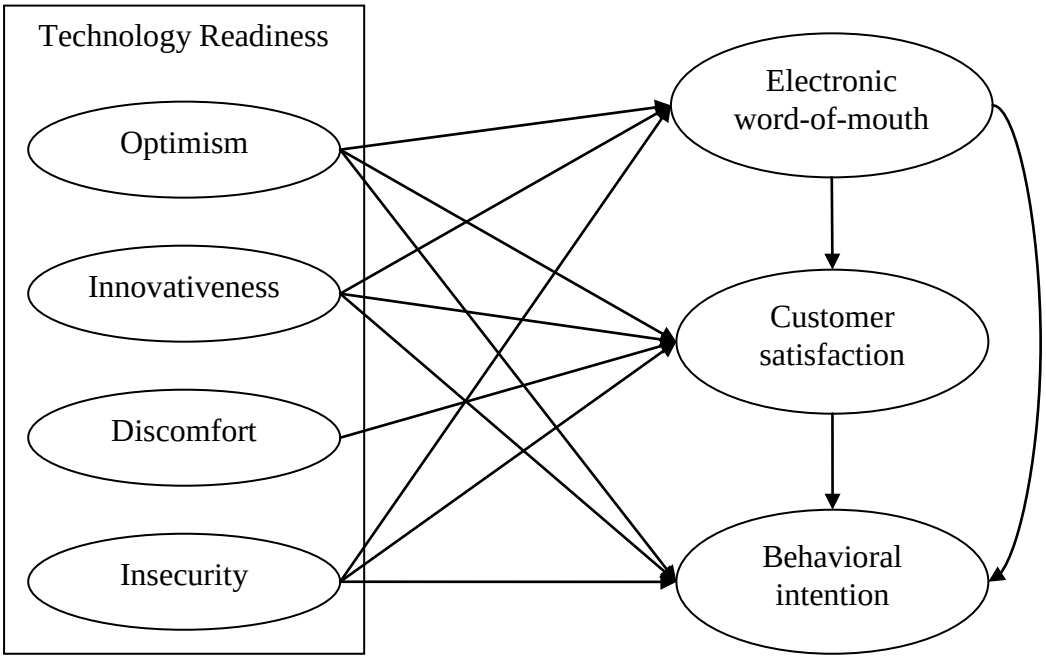

Figure 1: Research model.

The formal questionnaire contains 9 parts. The first part of the questionnaire asks respondents about their experiences of purchasing 3C products. The second part of the questionnaire asks respondents about their willingness to refer to the electronic word-of-mouth before purchasing 3C products. The third part of the questionnaire is used to understand if respondents are satisfied with the 3C products they have bought. The fourth

part of the questionnaire is used to understand respondents' behavioral intention. The fifth part of the questionnaire is used to measure respondents' perception of optimism. The sixth part of the questionnaire is used to measure respondents' perception of innovativeness. The seventh part of the questionnaire is used to measure respondents' perception of discomfort. The eighth part of the questionnaire is used to measure respondents' perception of insecurity. The last part of the questionnaire is used to understand the background of the respondents, such as their sex, age, marriage status and level of education. There are 38 questions in total.

The questions in the remaining parts of the questionnaire are measured by the seven point Likert scale, ranging from 7 (strongly agree) to 1 (strongly disagree).

Research subjects in this research were focused on consumers who have the experience of purchasing 3C products. The on-line questionnaire was used to collect data, and the on-line questionnaire was posted on http://www.my3q.com/ which is a professional questionnaires posting website and is free for academic purpose in conditions. Furthermore, the web link of the on-line questionnaire was also sent to research subjects by email and was posted on Facebook. The collection period was from the 16th of August to the 30th of August, 2010. A total of 184 questionnaires were collected. However, there were 24 invalid questionnaires, for example, the questionnaires with all the questions being answered in the same scale. Consequently, the number of the final valid questionnaires was 160.

ANALYSIS AND RESULT

In order to analyze the data which are collected from the questionnaires, statistic software such as Microsoft Excel, SPSS 12.0 and AMOS 6.0 are used. Mean and standard deviation of each measurement item are calculated and showed in Table 1.

Table 1: Mean and standard deviation of each measurement item.

Code	Serial Number	Mean	Standard deviation
WOM	Q3	6.16	0.99
	Q4	5.58	1.23
	Q5	5.91	1.07
SAT	Q6	5.85	0.97
	Q7	5.51	1.06
	Q8	5.28	1.12
	Q9	4.81	1.15
	Q10	5.36	1.06
BI	Q11	6.16	0.82
	Q12	5.83	0.99
	Q13	6.07	0.91
OPT	Q14	5.58	1.05
	Q15	5.50	1.12
	Q16	5.85	0.96
	Q17	5.45	1.22
	Q18	5.59	1.18
	Q19	5.70	1.00
	Q20	5.07	1.23
INNO	Q21	4.96	1.38
	Q22	5.00	1.43
	Q23	4.13	1.57
	Q24	4.86	1.39
	Q25	5.01	1.34
	Q26	5.23	1.20
	Q27	4.80	1.32
DIS	Q28	5.49	1.05
	Q29	5.22	1.17
	Q30	5.24	1.28
	Q31	4.48	1.33
INS	Q32	4.93	1.34
	Q33	4.81	1.38
	Q34	5.28	1.23
	Q35	4.68	1.38

Reliability and validity test

In order to test the reliability and validity of the data gathered from the questionnaires, Cronbach's α value and the average variance extracted are calculated and showed in Table 2. According to Pallant (2007), Cronbach's α value is used to test the reliability, and 0.7 is the minimum level for Cronbach's α value. In Table 2, the Cronbach's α values of all variables are greater than 0.7, and it means the internal consistency is acceptable and the results of the questionnaires are highly stable and accurate. The average variance extracted is used to test the convergent validity. Fornell and Larcker (1981) suggest that 0.5 is the minimum level for the value of the average variance extracted. In Table 2, the average variance extracted values

of all variables are greater than or equal to 0.5, and it means that the convergent validity is acceptable. Since the reliability and validity test of the questionnaire are all acceptable, the result of the analysis can be seen as believable.

Table 2: The result of reliability and validity test.

Code	Serial Number	Cronbach's α	Average variance extracted
WOM	Q3 ~ Q5	0.76	0.51
SAT	Q6 ~ Q10	0.90	0.65
BI	Q11 ~ Q13	0.88	0.70
OPT	Q14 ~ Q20	0.91	0.60
INNO	Q21 ~ Q27	0.93	0.70
DIS	Q28 ~ Q31	0.79	0.50
INS	Q32 ~ Q35	0.89	0.68

Overall model fit

The overall model fit is used to test the fitness for the research model and the data collected from the questionnaires. The fit indexes are computed and showed in Table 3. The recommended minimum value of GFI (Goodness of Fit Index) is 0.9, and the recommended minimum value of AGFI (Adjusted Goodness of Fit Index) is 0.9 (Hu and Bentler, cited in Hsiu 2007). Moreover, the recommended minimum value of RFI (Relative Fit Index) and NFI (Normed Fit Index) are both 0.9 (Hsiu, 2007), and the recommended minimum value of PGFI (Parsimony Goodness of Fit Index) is 0.5. According to Table 3, all the fits indexes in this research reach the recommended values which mean that the overall model fit in this research is acceptable.

Table 3: Overall fitness of models.

Fit index	Recommended Value	Measurement model	Structural model
GFI	>= 0.90	0.97	0.97
AGFI	>= 0.80	0.97	0.96
PGFI	>= 0.50	0.82	0.82
NFI	>= 0.90	0.96	0.96
RFI	>= 0.90	0.96	0.96

Hypotheses tests

In order to test those hypotheses which are made in this research, AMOS software is used to compute the path coefficient values between the variables in the research model. If the path coefficient value between two variables is greater than 0.1, it means that there is a positive relationship between these two variables. If the path coefficient value between two variables is smaller than -0.1, it means that there is a negative relationship between these two variables. Otherwise, it is said that there is no strong relationship between these two variables. According to the results computed by AMOS, the path coefficient values in this research model are showed in Figure 2.

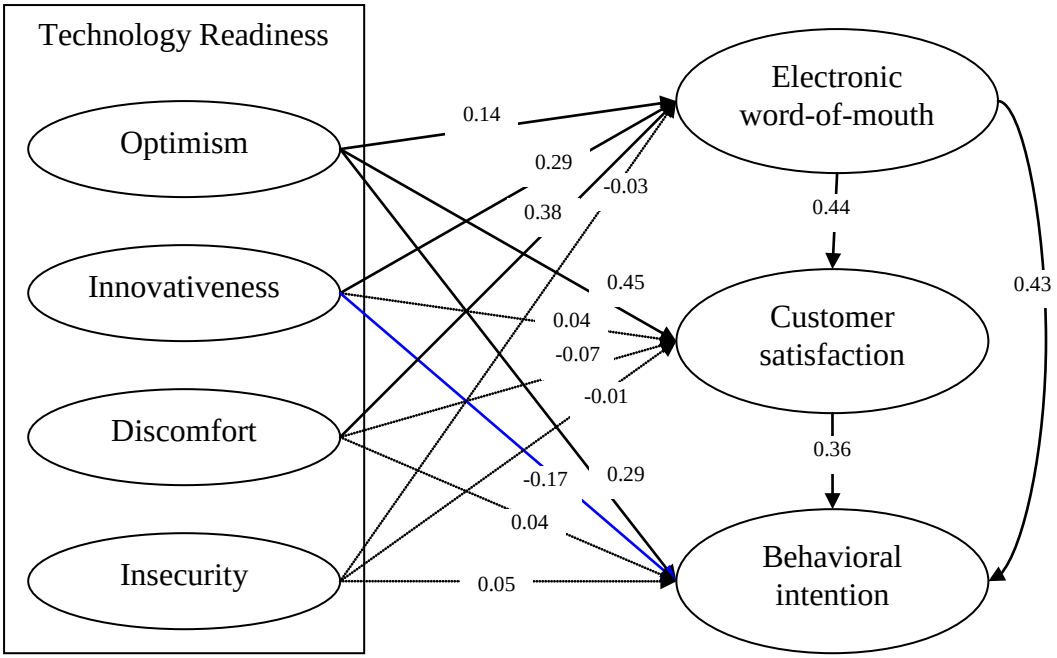

Figure 2: Path coefficient values of research model.

According to Figure 2, the path coefficient value between optimism and electronic word-of-mouth is 0.14 which is greater than 0.1, and thus hypothesis H_{1a} is supported by the analysis result. It means that the optimism about technology positively influences the willingness to refer to the electronic word-of-mouth. The path coefficient value between optimism and customer satisfaction is 0.45 which is greater than 0.1, and thus hypothesis H_{1b} is supported by the analysis result, meaning that the optimism about technology has a positive influence on customer satisfaction. The path coefficient value between optimism and behavioral intention is 0.29 which is greater than 0.1, and thus hypothesis H_{1c} is supported by the analysis result, which means that the optimism about technology positively influences behavioral intention.

The path coefficient value between innovativeness and electronic word-of-mouth is 0.29 which is greater than 0.1, and thus hypothesis H_{2a} is supported by the analysis result, which means that the innovativeness about technology positively influences the willingness to refer to the electronic word-of-mouth. The path coefficient value between innovativeness and customer satisfaction is 0.04 which is smaller than 0.1 and greater than -0.1, and therefore hypothesis H_{2b} is not supported by the analysis result, which means that there is no strong relationship between the innovativeness about technology and customer satisfaction. The path coefficient value between innovativeness and behavioral intention is -0.17 which is smaller than 0.1, and therefore hypothesis H_{2c} is not supported by the analysis result. However, the path coefficient value is smaller than -0.1, indicating that the innovativeness about technology have a negative influence on behavioral intention.

The path coefficient value between discomfort and electronic word-of-mouth is 0.38 which is not smaller than -0.1, and therefore hypothesis H_{3a} is not supported by the analysis result. Nevertheless, the path coefficient value is greater than 0.1, demonstrating that the discomfort about technology positively influences the willingness to refer to the electronic

word-of-mouth. The path coefficient value between discomfort and customer satisfaction is -0.07 which is smaller than 0.1 and greater than -0.1, and therefore hypothesis H_{3b} is not supported by the analysis result, showing that there is no strong relationship between the discomfort about technology and customer satisfaction. The path coefficient value between discomfort and behavioral intention is 0.04 which is smaller than 0.1 and greater than -0.1, and thus hypothesis H_{3c} is not supported by the analysis result, revealing that there is no strong relationship between the discomfort about technology and behavioral intention.

The path coefficient value between insecurity and electronic word-of-mouth is -0.03 which is smaller than 0.1 and greater than -0.1, and thus hypothesis H_{4a} is not supported by the analysis result, which indicates that the insecurity about technology and the willingness to refer to the electronic word-of-mouth is not strongly related. The path coefficient value between insecurity and customer satisfaction is -0.01 which is smaller than 0.1 and greater than -0.1, and therefore hypothesis H_{4b} is not supported by the analysis result, which shows that the insecurity about technology does not have a significant relation with customer satisfaction. The path coefficient value between insecurity and behavioral intention is 0.05 which is smaller than 0.1 and greater than -0.1, and thus hypothesis H_{4c} is not supported by the analysis result, which demonstrates that there is no strong relationship between the insecurity about technology and behavioral intention.

The path coefficient value between the willingness to refer to the electronic word-of-mouth and customer satisfaction is 0.44 which is greater than 0.1, and thus hypothesis H_5 is supported by the analysis result, meaning that the willingness to refer to the electronic word-of-mouth positively influences customer satisfaction.

The path coefficient value between customer satisfaction and behavioral intention is 0.36 which is greater than 0.1, and thus hypothesis H_6 is supported by the analysis results, indicating that customer satisfaction positively influences behavioral intention.

The path coefficient value between the willingness to refer to the electronic word-of-mouth and behavioral intention is 0.43 which is greater than 0.1, and therefore hypothesis H_7 is supported by the analysis result, showing that the willingness to refer to the electronic word-of-mouth positively influences behavioral intention.

The testing results of the hypotheses are summarized in Table 4. According the hypotheses testing results, it is obvious to see that people who are optimistic about technology are more willing to refer to the electronic word-of-mouth before purchasing 3C products. Moreover, after purchasing these products, they are more satisfied with the products they have bought, and they would like to repurchase the products and recommend others to buy the same products. Their customer satisfaction is relatively high because they usually make more preparations before purchasing the products. Besides, because they are more satisfied with the products, they are more willing to recommend the products to others.

People with the perception of the innovativeness about technology are also willing to refer to the electronic word-of-mouth before buying 3C products. However, according to the research results, there is no strong relationship between the innovativeness about technology and their customer satisfaction. It might be because people with the perception

of the innovativeness about technology usually want to be the pioneers of trying new 3C products and there may not be enough information about those products and support from manufacturers at that time. As a result, they may not always be satisfied with the products they have bought. Nevertheless, according to the research results, their behavior intention is relatively low. It is opposite to the hypothesis in this research. The reason might be that they are always interested in new products, so the willingness to buy the same 3C products is relatively low. In addition, their intention to recommend the products to others is influenced by their customer satisfaction, so their behavioral intention is not as strong as what is hypothesized.

Table 4: Summary of the hypotheses testing result.

	Hypothesis	**Results**
H_{1a}	**The optimism positively influences the willingness to refer to the electronic word-of-mouth.**	**Supported**
H_{1b}	**The optimism positively influences customer satisfaction.**	**Supported**
H_{1c}	**The optimism positively influences behavioral intention.**	**Supported**
H_{2a}	**The innovativeness positively influences the willingness to refer to the electronic word-of-mouth.**	**Supported**
H_{2b}	**The innovativeness positively influences customer satisfaction.**	**Not supported**
H_{2c}	**The innovativeness positively influences behavioral intention.**	**Not supported**
H_{3a}	**The discomfort negatively influences the willingness to refer to the electronic word-of-mouth.**	**Not supported**
H_{3b}	**The discomfort negatively influences customer satisfaction.**	**Not supported**
H_{3c}	**The discomfort negatively influences behavioral intention.**	**Not supported**
H_{4a}	**The insecurity negatively influences the willingness to refer to the electronic word-of-mouth.**	**Not supported**
H_{4b}	**The insecurity negatively influences customer satisfaction.**	**Not supported**
H_{4c}	**The insecurity negatively influences behavioral intention.**	**Not supported**
H_{5}	**The willingness to refer to the electronic word-of-mouth positively influences customer satisfaction.**	**Supported**
H_{6}	**Customer satisfaction positively influences behavioral intention.**	**Supported**
H_{7}	**The willingness to refer to the electronic word-of-mouth positively influences behavioral intention.**	**Supported**

According to Figure 2, there is no strong relationship between the discomfort about technology and customer satisfaction, and there is no strong relationship between the discomfort about technology and behavioral intention either. However, according to the research results, it is found that people with the perception of discomfort about technology are more willing to refer to the electronic word-of-mouth before buying 3C products, and this finding is opposite to the hypothesis H_{3a}. The possible reason is that they are not confident of selecting the right 3C products, so they would like to refer to the electronic word-of-mouth in order to understand other consumers' opinions and experiences.

According to the research results, it is found that the relationships between the perception of insecurity about technology and the willingness to refer to the electronic word-of-mouth, customer satisfaction and behavioral intention are not as strong as what are hypothesized in the beginning of this research.

From Figure 2, it shows that people who are more willing to refer to the electronic word-of-mouth before purchasing 3C products are more satisfied with the products they have bought. It is because referring to the electronic word-of-mouth helps customers to reduce the risk of buying unsuitable products and to gain more information. Consequently, their expectation of the 3C products should be easier to be reached. What is more, the analysis results also show that people who are more willing to refer to the electronic word-of-mouth before purchasing 3C products have a greater tendency to repurchase and recommend the products to others. The possible reason is that they are satisfied with the products which they have bought, and they would like to share their positive experience with their friends and families.

Lastly, it is found that people who are more satisfied with the 3C products they have bought are more inclined to repurchase and recommend the products to others. It is because their experience of purchasing these products is delightful. As a consequence, their behavioral intention is relatively higher.

DISCUSSION AND CONCLUSION

The purposes of this research are to understand if the electronic word-of-mouth has an influence on the customer satisfaction and behavioral intention when they purchase 3C products and to give recommendations for improving the effectiveness of the electronic word-of-mouth in 3C products industries.

In section one, the motives and the goals in this research work are introduced. 3C products industry changes very fast and is highly competitive. The Internet plays an important role in exchanging the information and all kinds of experiences of purchasing 3C products. In order to promote new products effectively and increase customer satisfaction, utilizing the power of the electronic word-of-mouth is essential for manufacturers. In addition, in order to deliver the electronic word-of-mouth efficiently, targeting the opinion leaders on the Internet accurately is necessary.

In section two, some literatures about this research work are reviewed. Firstly, literatures about word-of-mouth, the electronic word-of-mouth and opinion leaders are discussed. Secondly, literatures about technology readiness as well as the four dimensions of measuring technology readiness index are talked about. Thirdly, literatures about customer satisfaction and its importance are discussed. Fourthly, literatures about behavioral intention are mentioned.

In section three, the methodology which is used in this research is introduced. Firstly, the research model in this research work is made. Secondly, according to the research model, 15 hypotheses are made in order to find out the relationships between 7 variables. Thirdly, the reasons for surveying by means of questionnaires are explained. Fourthly, the pilot test and the questions in the formal questionnaires are introduced. Lastly, the sampling method which is used to collect data is introduced.

The data which are collected from questionnaires are analyzed in section four. Simple statistic data about the background of 160 respondents are introduced first. The reliability and validity test are conducted, and then the overall model fit is measured as well. After the tests of 15 hypotheses, the hypotheses test results and findings are introduced in the last part.

The conclusions, suggestions and limitations of this research are given in the following.

Conclusions and suggestions

According to the analysis results, it is obvious that the electronic word-of-mouth plays an important role in 3C products industry. Customers' willingness to refer to the electronic word-of-mouth before purchasing 3C products positively influences customer satisfaction and behavioral intention. It means that the information and opinions from other consumers on the Internet strongly affect customers' decisions to purchase certain products. Furthermore, it is found that customers who are satisfied with the 3C products they have bought are more willing to repurchase and to recommend these products to their friends and families. Therefore, the positive word-of-mouth is spread. In view of these, following suggestions are made for 3C products manufacturers in order to promote their products more effectively and increase customer satisfaction and consumers' behavioral intention.

1. 3C products manufacturers should cooperate with professional online discussion forums. Nowadays, there are too many advertisements in the public media, and customers are forced to ignore most of them. Therefore, the electronic word-of-mouth has become one of the most efficient approaches for consumers to gain the information about new 3C products. There are many professional online discussion forums which provide platforms for Internet users to express their experiences and opinions about 3C products. 3C manufacturers should cooperate with these online discussion forums and deliver the information about their products there.

2. 3C products manufacturers should always pay attentions to customers' opinions on the Internet. Sometimes the dissatisfying customers express their complaints on professional online discussion forums instead of responding to the customer service department of manufacturers. Since the effect of negative word-of-mouth is stronger than the positive one, manufacturers have to understand the complaints from customers on the Internet and to solve their problems in order to stop the spread of the negative word-of-mouth and increase customer satisfaction. Thus, 3C products manufacturers have to pay attention to professional online discussion forums and give resolutions to consumers' problems. In this way, customer satisfaction can be improved and the positive electronic word-of-mouth can be increased as well.

3. 3C products manufacturers should make the instructions and the information of their products easier to be understood. According to the analysis results, people with the perception of discomfort about technology are willing to refer to the electronic word-of-mouth before purchasing 3C products. However, these people are not confident of using new technologies and feel a lack of control over new technologies. In order to increase their customer satisfaction, manufacturers should help them to understand new 3C

products more effortlessly. In addition to providing more detailed instructions and information of products, manufacturers could answer their questions about products on the professional online discussion forums.

According to Rosen (2001), opinion leaders are interested in trying new things and sharing their experiences with others, and they are information-hungry and like to search for information online. According to Parasuraman and Colby (2001), both the perception of optimism and innovativeness are the contributors of technology readiness, and people with the perceptions of optimism and innovativeness about technology have higher technology readiness. Thus, the characteristics of opinion leaders are similar to those of the people who have higher technology readiness. Therefore, opinion leaders can be seen as people who usually have higher technology readiness.

According to the analysis results, it is found that people with the perception of optimism and innovativeness about technology usually refer to the electronic word-of-mouth before buying 3C products. This also means that opinion leaders are more willing to refer to the electronic word-of-mouth before purchasing 3C products. Therefore, dealing with the electronic word-of-mouth is essential for 3C products manufacturers. In order to utilize the power of the electronic word-of-mouth more effectively, the following suggestions are made for 3C products manufacturers.

1. 3C products manufacturers should focus more on the opinion leaders on the Internet. Although manufacturers could convey the information about their products directly to their customers by themselves, it is easy for customers to treat this kind of information as advertisements. Since opinion leaders have the ability to influence other people's decisions, manufacturers should cooperate with online opinion leaders and spread the information through them. There are many cooperation approaches, such as giving them free products, inviting them to the exhibitions, providing trial products, giving them a price discount and so on. Those online opinion leaders can affect other customers and other opinion leaders, so the electronic word-of-mouth about 3C products can be spread efficiently.

2. 3C products manufacturers should provide more technical support to those pioneers of purchasing new products. According to the analysis results, people with the perception of innovativeness about technology whose customer satisfaction and behavioral intention are not as high as expected. The possible reason is that there may not be enough technology support for the latest products from manufacturers. Since opinion leaders also have the perception of innovativeness about technology, 3C products manufacturers should be aware of their feedback and provide more advanced support to these pioneers in the first time. By providing them with more technical support and advanced information, these opinion leaders' customer satisfaction and behavioral intention can be improved. Furthermore, the positive word-of-mouth is created.

Limitation and future work

In this research work, due to the limited time and resources, the main limitation is that the samples of the questionnaires are not enough. There are only 160 available questionnaires

which are analyzed in this research. Among these questionnaires, there are 97% of the respondents whose ages are between 21 and 40, and there are 94% of the respondents who have Bachelor's or Master's degrees. Because the samples are not enough, the analysis results might not be able to reflect a real condition precisely.

In the future work, it is suggested considering more samples of the questionnaires. Besides, the research focuses on 3C products industry, so it is also suggested surveying different industries, for example the car industry, in order to understand the effect of the electronic word-of-mouth in different areas.

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TQM AND QFD APPROACH TO ACHIEVE CUSTOMER SATISFACTION: A FLOUR MILLING COMPANY CASE STUDY

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ABSTRACT

The paper sets out to present the results of a survey of customer satisfaction with regard to the strategy of Total Quality Management (TQM) adopted in a wheat flour milling company. This survey was conducted to learn more about customer expectations and satisfaction. The respondents were all customers of a flour-based food processor. Quality Function Deployment (QFD) was applied to improve customer service performance by focusing on Customer Satisfaction, Value and Retention. The results show that customer satisfaction has increased steadily over a period of three years. The QFD approach helped to design a competitive product by aligning the company resources to customers' needs. The findings are limited to a specific food manufacturing company and for this reason they cannot be generalized to the whole in service sector. Further research is needed for other service companies. The findings may support manufacturing companies hoping to achieve customer satisfaction by focusing on total quality management implementation efforts. Furthermore, companies can focus their efforts on improving the way in which they meet certain customers' needs if these needs are more extensively related to a certain component of quality management. It presents evidence to the managers of the value of implementing TQM strategy to effectively achieve customer satisfaction that ultimately leads to greater market share and profit maximization.

Keywords: Manufacturing, Total quality management, Quality function deployment, Customer satisfaction, Benchmarking

INTRODUCTION

Over the past two decades, companies have been experiencing dramatic changes in the business environment characterized by such phenomena as increasing consumer awareness of quality, the rapid transfer of technology, globalization and competition to reduce costs. In response to these challenges, many companies have joined the quality faction and implemented various quality improvement initiatives as a means to enhance competitiveness and ultimately business performance. While the business world also shifts its focus from product to customer, managers are discovering that profitable and sustainable revenue growth results from enhanced customer relations, because consumers nowadays are more informed, more demanding, and prone to change brands and

companies if their requirements are not met on time and at a price they are willing to pay (Andronikidis et al., 2009).

However, quality is considered the ability to meet the stated and implied requirements of customers and not an inherent feature (Shahin and Nikneshan, 2008). The effectiveness of quality initiatives resulting in sustainable competitive advantage and enhanced business performance has been a major subject of interest for business (Arumugam et al., 2009). Understanding customers' expectations is a prerequisite for delivering superior products, because they represent the implicit performance standards which customers use in assessing product quality (Parasuraman, 1998). Total Quality Management (TQM), as a set of management practices, focusing on customer satisfaction and constant organizational development, has been widely adopted (Dale, 1999; Yusof and Aspinwall, 2000).

Through TQM practices, companies have been trying to improve product quality to earn customer satisfaction, besides their overall performance (Bhat and Rajashekhar, 2009). But an image of the kind of TQM strategy which will efficiently earn this satisfaction in manufacturing industry is still vaguely presented. Most companies naturally focus on improving the quality of the product, while service quality – the steps taken to deliver the product – is not generally given priority. Thus, it is helpful for companies to know and understand the current practices and opportunities offered by TQM if they want pursue customer satisfaction by combining improvements in the product with those in the quality of service.

To provide a comprehensible image of TQM strategy in a manufacturing company, the present study collects data from a 'Voice of the Customer' survey, which describes how customers (in this case, of a small to medium-sized enterprise – hereafter, SME – in the food industry, processing wheat flour) appreciate quality in products and services. The main research question of this paper is as follows:

- How TQM can be implemented to achieve customer satisfaction in terms of quality of products and services?

The data are analyzed by the QFD method to gauge the level of customer satisfaction with products and service and to establish action plans for developing the potential of both. QFD is chosen since it is a form of strategic planning to accomplish TQM and is essential for quality initiatives to be successful (Juran, 1989).

In the light of the above, this paper is structured as follows. Section 2 reviews the theories laid down in the studies of customer satisfaction, with special reference to the case under review. Section 3 presents quality and TQM concepts by discussing the TQM implementation programme in the case company. Section 4 provides a snapshot of the analysis and measurement process of TQM success in the case company. Finally, Section 5 is devoted to conclusions and implications.

CUSTOMER SATISFACTION

Defining customer value and satisfaction

Customers choose products or services from a selection of different kinds on the basis of pre-perceived value for the product. Value can be defined as a ratio between what the customer gets and what he gives. The customers get benefits and assume costs. The benefits include functional benefits and emotional benefits. The costs include monetary costs, time costs, energy costs, and physics costs. Thus value is given by:

$$\text{Value} = \frac{\text{Benefits}}{\text{Costs}} = \frac{\text{Functional benefits + emotional benefits}}{\text{Monetary costs + time costs + energy costs + psychic costs}}$$

During and after the consumption and use of a product or service, customers will develop feelings of satisfaction or dissatisfaction (Kotler and Armstrong, 1996; Kotler, 2000). Customer (dis)satisfaction is defined as the overall attitude of customers toward a good or service after they have acquired and used it. It is a post-choice evaluation which results from selecting a specific purchase and the experience of using/consuming it (Malhotra, 1999). From the managerial perspective, maintaining and/or enhancing satisfaction is critical. Most studies reveal that satisfied customers positively influence a company's future cash flows (Pande et al, 2000). Managers should therefore in their overall business process create programmes to increase customer satisfaction.

However, it is necessary to recognize the factors which contribute to customer satisfaction or dissatisfaction. Figure 1 presents a model of customer satisfaction with regard to their consumption/use of product or service. On the basis of this experience, they evaluate its overall performance. This action has been found to relate precisely to the ratings of quality of product and/or service. Customers compare their perceptions of product/service quality after using the product with their expectation before they purchase it. It also depends on how far actual performance reflects expected performance; customers may that experience positive, negative, or neutral emotions. These emotional responses act as inputs into their overall satisfaction/dissatisfaction perception.

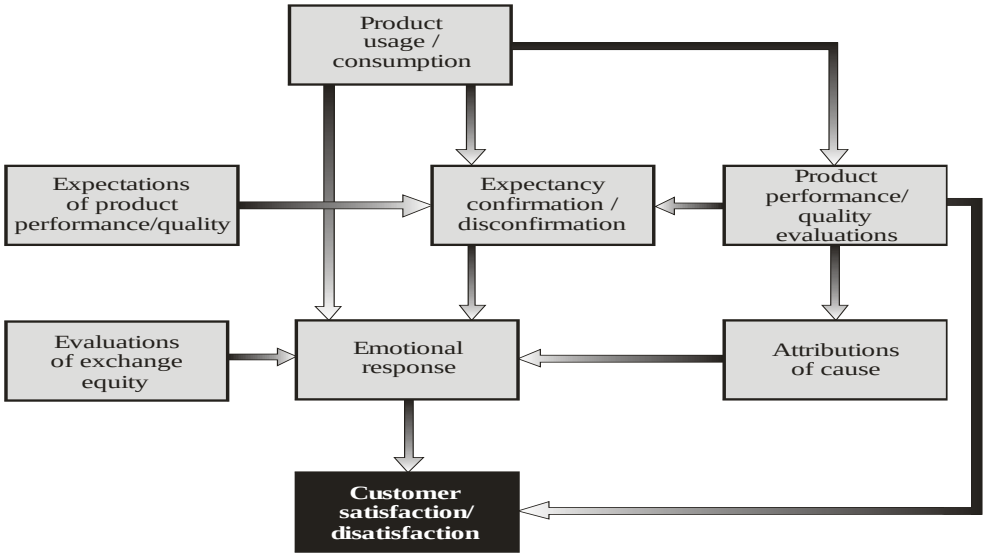


Figure 1: A model of customer satisfaction/dissatisfaction.

The level of satisfaction/dissatisfaction will also be affected by customers' evaluation of the equity of the exchange and also by their attributions of the cause of the product's performance.

IMPLEMENTING TOTAL QUALITY MANAGEMENT.

Quality and TQM.

Different specialists have defined quality as 'fitness for use', 'conformance to requirements' and 'freedom from variation'. One further short definition of quality is also 'customer satisfaction and loyalty'. We use two definitions of quality, for either products or services, as follows:

■ 'The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied customers' needs' (Kotler, 2000).

■ Quality must provide goods and services that completely satisfy the needs of both *internal* and *external customers*. Quality serves as the 'bridge' between the producer of goods or services and the customer (Johnson & Weinstein, 2004).

Quality is the key to value creation and customer satisfaction. In a quality-centred company, a marketing manager has two responsibilities. First, he should participate in formulating strategies and policies designed to help the company win through the excellence of its quality. Second, he should deliver marketing quality alongside production quality. Each marketing activity – market research, sales training, advertising, customer service and so on – must be performed to high standards. Marketers play several roles in helping their companies to define and deliver high quality products and services to its target customers. Figure 2 shows the role of marketing between company and customer in this process.

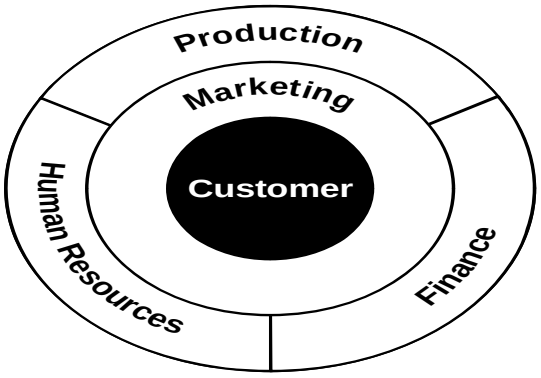


Figure 2: Evolving views about the role of marketing in the company (Kotler, 2000).

TQM is basically a strategy (towards continuous change), as well as an operationalized process, and can be also described as a holistic approach which seeks, through the improvement of quality, productivity and competitiveness (Pfau, 1989), to integrate all organizational functions and organizational objectives in a focus on meeting customer needs (Kumar et al., 2008) . It emphasizes the role of internal and external customers and suppliers, and the involvement of employees in a quest for continuous improvement (Oakland et al., 2002; Kanji, 2002; Karia and Asaari, 2006; Chang, 2006). TQM allows firms to obtain, on the one hand, a high degree of differentiation, satisfying customers' needs and strengthening brand image, and, on the other, to reduce costs by preventing mistakes and wasted time and by making improvements in the corporation's processes (Conca et al., 2004). It encompasses and facilitates all functional areas, processes and systems of businesses, including design, development, production, distribution and customer support (Jung et al., 2008). This holistic approach aims to maximize customer satisfaction upon a basis of repeating activities in the interests of innovation and advancement (Dessler, 2003; Ross, 1998; Yang, 2005).

According to Gill (2009), quality in a product makes sure that it can meet the present expectations of the customer takes account of or incorporates future needs. Indeed, the implementation of quality is the main focus in TQM philosophy. However, TQM companies need to define quality for themselves, whether the definition is intended to meet engineering standards, or is a leading edge definition to make a product which animates customers and which customers would not think of buying from competitors. With a clear definition of quality the company can start to focus on a target for change but if no one agrees on the definition of quality it is difficult to focus on implementing changes which will improve quality.

Scope of quality management

According to Klefsjö et al. (2008), the scope of quality management has changed in recent years from 'customer satisfaction' to something broader. This trend may be due to companies' increasing focus on their multiple bottom lines. What is vital is the way in which companies decide to define the concepts of (i) customers (ii) non-customer stake-holders and (iii) interested parties.

Bergman and Klefsjö (2003) describe customers broadly as 'those companies want to create value for'. The notion of value is here related to value chains, not to the financial chains in the organization. A transitional definition which may be constructive is that customers are individuals or organizations further downstream in the product life cycle process, that is, they are the receivers of a product (Johansson, 2008). Individuals or organizations upstream in the same process would accordingly be named suppliers. Customers and suppliers can be internal or external, depending on the organizational boundaries of the actual process.

Freeman and Reed (1983) attach the term 'stakeholders' with those persons or groups that have a stakes in the organization. Klefsjö et al. (2008) think stakeholders are those actors that provide necessary means or support to the organization, which could be withdrawn if their wants or expectations are not met. They further suggest the term 'primary stakeholder' to be used for those actors who provide the necessary means or support for the organization and could withdraw these, leading to significant consequences for the organization. Examples of primary stakeholders could include customers, employees, investors, shareholders and government.

According to Klefsjö et al. (2008) 'interested parties' are those who have any interest in the organizational activities, output or outcome, although these parties lack power or instruments to create unacceptable damage for the organization or to influence the primary stake-holders to do so. Some actors, although not directly providing any of the necessary means or support to the organization, may still have enough influence to justify considering them more than mere interested parties. Those 'secondary stakeholders' may include nongovernmental organizations, academics, media, fair-trade bodies, environmental pressure groups and other individuals or organizations which somehow may manipulate stakeholders to act on their behalf, if their needs and expectations are ignored.

Implementing TQM for customer satisfaction

What should marketers do in order to raise customer satisfaction and ultimately improve company performance? In the course of the improvement period, they should address it from two sides:

- Product quality side: developing Quality Management Systems (QMS), implementing International Standard Organization, implementing supplier evaluation programmes (in this case, as a provider of wheat and packaging materials and additive material) and providing food safety assurance through health certification.

- Services side: Providing a training centre for food processing, allocating technical representatives for after-sales services, running promotion activities and hotline services to develop customer relationships (Moven, 2001), developing business information for sales and distribution by using the ERP system for online customer orders, payment systems, production planning and scheduling and connecting R&D to customers in order to meet specific customer wants.

Measuring customer value and satisfaction

Quality Function Deployment (QFD) is used to assess the quality of products and services from the customer's standpoint and to identify the prioritized items of product quality and service which can affect the improvement of the SME and also to plan designs for products and services which give high advantage to both the customer and the company (Besterfield and Besterfield 1994; Cohen, 1995) by creating product uniqueness and shortening product life (Urban and Hauser 1993).

QFD is defined as 'how we understand the quality that our customers expect and make it happen in a dynamic way' (Martins and Aspinwall, 2001; Chow-Chua and Komaran, 2002). QFD is also referred to as a 'House of Quality (HOQ)'. The logic behind this is that the matrix in QFD fits together to form a house-shaped diagram (Kutucuoglu et al., 2001). QFD involves a team of people representing the various functional departments which combine in product development, such as marketing, design engineering, quality assurance, manufacturing/manufacturing engineering, test engineering, finance, product support, etc. (Crow, 1996). Figure 3 shows how QFD is used to benchmark organization technical capabilities against customer requirements. It shows that continuous improvement is the basic need for implementing QFD through the House of Quality.

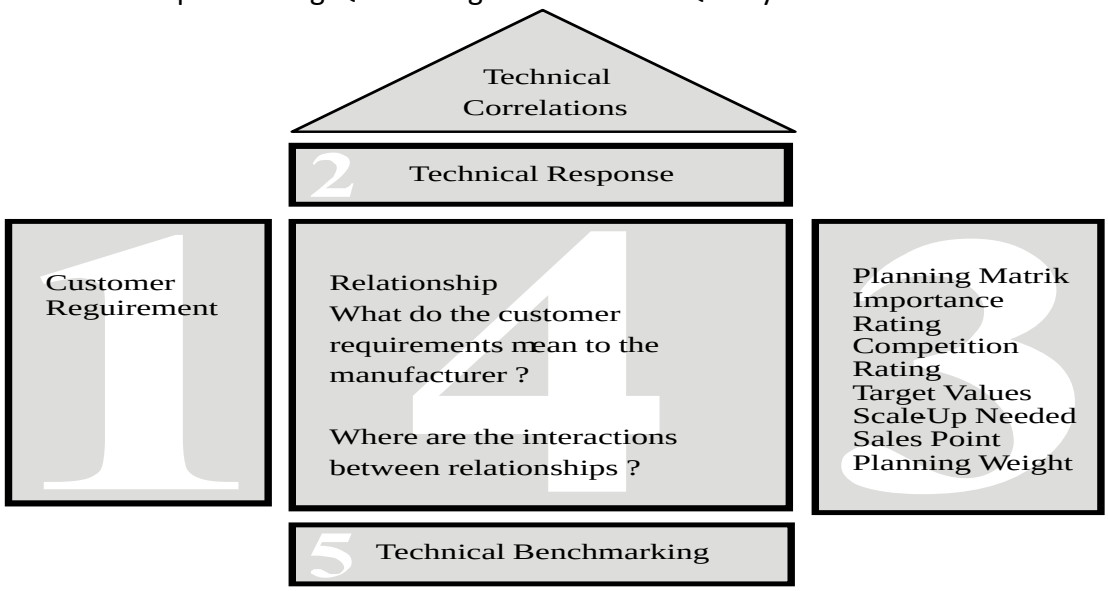


Figure 3: House of Quality for implementing QFD.

Customer satisfaction survey 2006

Observations were made of the case under review, a manufacturing company which is classified as an SME. Its main products are 3 classes of wheat flour products (high, medium and low protein content), divided into 16 brands with additional products, such as pellets, bran and pollard. We observed only wheat flour, since it accounts for 85% of the total sales. In addition, pellets, bran and pollard are consumed by the cattle and wood industries and are thus not as sensitive as those for the wheat flour customers. The product quality and customer service of the company were observed together with those of its three local

competitors and of the imported flour distributed in the market and the views of 150 customers were gathered; they bought various products (bread, noodles, biscuits, cakes, spring rolls, pastry and fried snacks) Sales regions and weekly consumption totals were also examined.

The observation was not concerned with the matter of product price. Surveys were conducted in 2006 and again in 2008.

Due to the low education levels of SME operators, the method was used of in-depth interviewing, on the recommendation of Churchill (1999), who suggests that this method is best suited to theory generation, in that in-depth interviewing allows the interviewer to change the wording of questions in accordance with the 'universe of discourse' (Gorden 1975), jargon and contextually specific phraseology and terminology of the informant.

The company used QFD for defining customer requirements (What), defining the technical correlation between customer requirements and technical response (How), planning the next improvement to meet customers' views and then defining which customer requirements should be prioritised, bearing in mind the manufacturing capability of the company. The following sections detail the steps of this process.

Defining "what" the customer requirements are (Step 1 in Figure 3)

Referring to customer value, functional benefits are defined as product quality attributes and emotional benefits are defined as service attributes. Table 1 presents both the product quality and service attributes that customers want ('what').

Table 1 was prepared by the marketing department of the company together with the product development section. The information was gathered in the course of discussion sessions. All the criteria in Table 1 are currently applied in the factory, marketing department and also in customer relationship management (CRM). Every Monday for three months the department heads of these sections held a management review meeting (MRM) convened by that was facilitated by the quality assurance (QA) department to formulate customer requirements. In addition, a quality consultant was also invited, whose job was to guide the managers in formulating these requirements through training and in-depth interviews.

Table 1: Customer requirements based on product quality and service quality.

Product Quality			Service	
Flour quality	Product Variety		Handling of customer complaints	Ease of calling
	Moisture			Responses
	Colour			Solutions
	Smoothness		Product availability	Anytime product taking
	Consistency			Reachable stations
	Foreign material (metal, plastic, yarn)			Ease of ordering
Hazard Protection	Brown spot			Delivery in place
	Product clump			Ease of getting information
	Insect		Product information	Production code
	Unpleasant odour			Brochure
Flour packaging	Variety of weights		Assistance	Training/exercise
	Stacking ability			Partnership
	Leak proof packaging			Entrepreneur consultancy
	Leak proof sewing			Sample product
	Imitation proof			Cookery contests
	Accuracy of weight			Cookery demos
Flour safety and quality warranties	Halal		Sales promotion	Advertising
	Healthy			Joint exhibitions
	International standard			Discounts
Fortification	Additive materials			Prizes
	Vitamin		Prize, bonuses & rewards	Rewards
				Credit terms and payment periods
Total	21 requirements		Total	22 requirements

Defining the technical correlation of "how" to meet the requirements (step 2 in Figure 3)

Once the customer requirements (22 requirements for service quality and 21 requirements for product quality) are listed (Table 1), the company should deploy the requirements into an action plan. Thus, a quantitative target should be established so that all the manufacturing, marketing and product development departments can carry out the plan. The company used a questionnaire for developing the action plan, containing 18 questions to cover product and service quality. Since the customers are not familiar with the Likert scale the salespersons of the company interviewed the customers and then interpreted the customers' answers in terms of the Likert scale.

The customers were asked how important the following needs were to them:

1. You need product information from a salesperson
2. You need a loan facility from the company
3. You need technical support for your production process related to the quality of the wheat flour

4. You need a quick response with delivery lead time of 1 day at maximum
5. You need a quick response with delivery lead time of 1 week at maximum
6. You need a transportation facility from the wheat flour manufacturer
7. You need direct access to the company's customer relationship management
8. You need online purchasing
9. You need wheat flour with low ash content for your product
10. You need finely-milled wheat flour for your product
11. You need wheat flour with neutral acidity of for your product
12. You are concerned about the protein content of the wheat flour used in your product
13. You are concerned about the fewer choices of wheat flours for your product
14. You need customised packaging of the wheat flour for your product
15. You need multi-purpose wheat flour for your product
16. You need wheat flour for your product which has been stored longer.

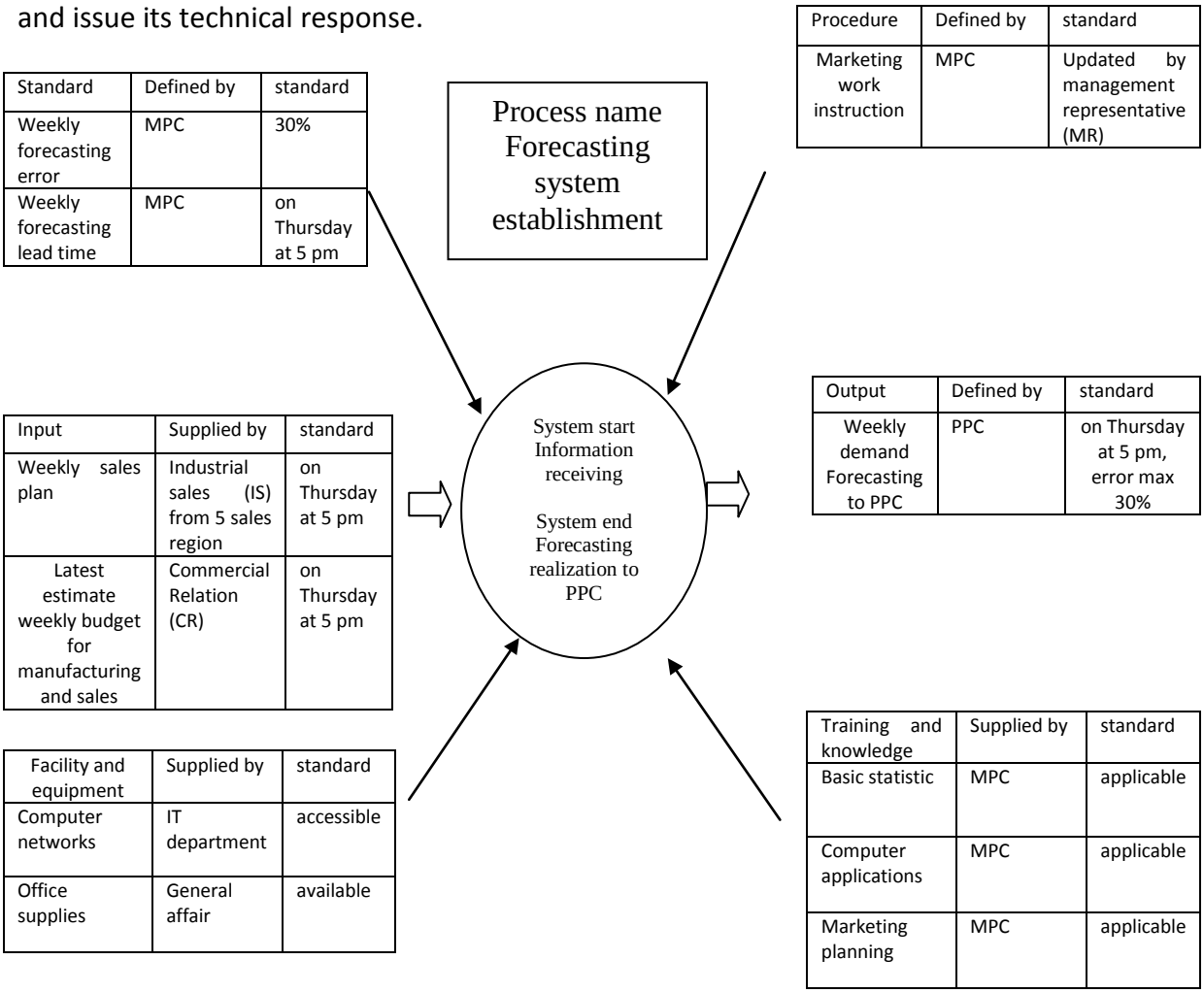
The answers to all these questions were scaled on a Likert scale from not very important, not important, fairly important and important to very important. The technical requirements arising from these answers guide a company in responding to customer wants and needs.

Developing a planning matrix and and building relationships between customer requirements and the company action plan (steps 3 and 4)

One of the important outcomes of the MRM was that a process model sheet replaced the analytical hierarchy process (AHP) which had always been used before in QFD implementation. This is because the company wanted to introduce a planning matrix of the simplest kind, to avoid confusion among the managers. In addition, the resulting technical response was meant to satisfy customer requirements; it had to be measurable and global in nature because it represents all the stakeholders of the quality attribute.

The first step is to construct a planning matrix. To take the example of product availability, we see from Figure 3 in the input/output analysis of the planning matrix, that resources (facility and equipment, training and knowledge, quality standards, working instruction and work plan) are benchmarked against customer requirements in the output matrix.

The company applies the process model sheet to determine and issue its technical response.



Standard	Defined by	standard
Weekly forecasting error	MPC	30%
Weekly forecasting lead time	MPC	on Thursday at 5 pm

Procedure	Defined by	standard
Marketing work instruction	MPC	Updated by management representative (MR)

Input	Supplied by	standard
Weekly sales plan	Industrial sales (IS) from 5 sales region	on Thursday at 5 pm
Latest estimate weekly budget for manufacturing and sales	Commercial Relation (CR)	on Thursday at 5 pm

Output	Defined by	standard
Weekly demand Forecasting to PPC	PPC	on Thursday at 5 pm, error max 30%

Facility and equipment	Supplied by	standard
Computer networks	IT department	accessible
Office supplies	General affair	available

Training and knowledge	Supplied by	standard
Basic statistic	MPC	applicable
Computer applications	MPC	applicable
Marketing planning	MPC	applicable

Figure 4: Process model sheet for meeting product availability requirement with manufacturer's capability.

Figure 4 develops step 4 for product availability ('how'); we see that the stakeholders in this step are the departments of production planning control (PPC), marketing planning control (MPC), information technology (IT) and the suppliers. The marketing department gathers information from the customers, which is then translated by the MPC according to its attributes. MPC then communicates the list of customer wants to the PPC in order to with the help of IT.

Making a development planning matrix (step 3 Figure 3) and prioritizing actions and finding the relationship of the matrix to the manufacturing strategy (step 4 Figure 3) are the result of a root cause analysis (Figure 4) and the development of action plans (Figure 5). These action plans are applied in the company where their effectiveness is periodically evaluated. This effectiveness will be the performance indicator of the success of QFD.

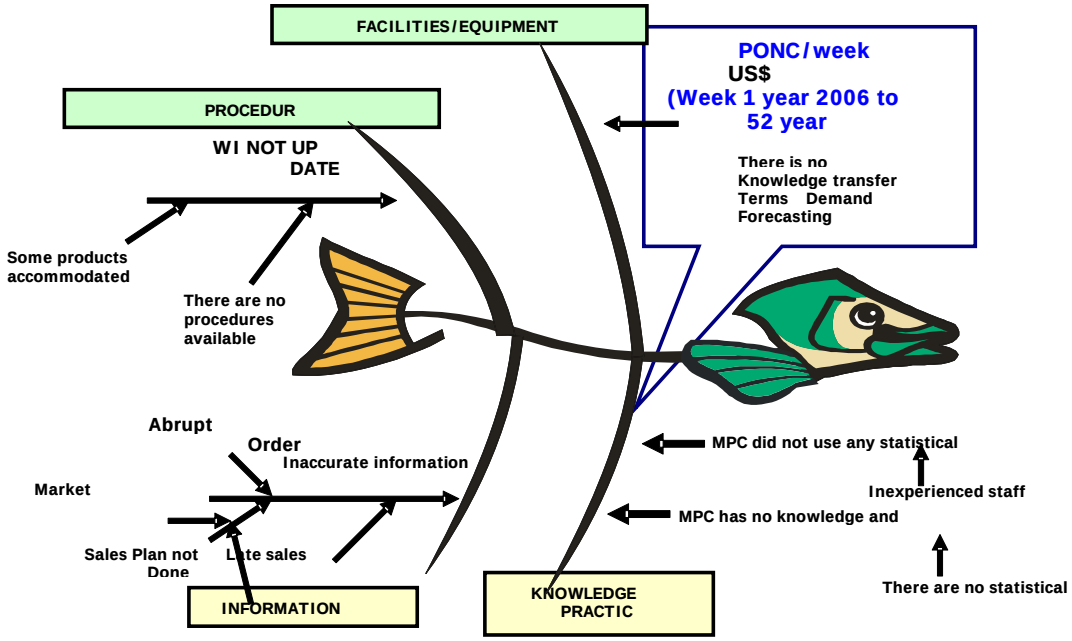


Figure 5: Root cause analysis of delivery lateness due to loss of product availability which incurs a price of non-conformance (PONC) as high as **US$ 20.987 per week**

Figure 5 shows the operability of root cause analysis by using a fish bone diagram. The company broke down the product availability problem into four areas, namely, facility and equipment problems, system and procedure problems, information flow problems and a resources (knowledge and practices) problem. From the Price of Non-Conformance (PONC) analysis, the company found that the biggest losses came from the knowledge sharing problem, which meant that lack of knowledge cost as much as US$ 20.987 per week. This loss came from, for instance, back orders, cancelled contracts, etc. From this analysis, the company created an action plan, as shown in Table 2.

Table 2: Action plans for accomplishing QFD.

What	Why	How	When	Where	Who
Statistical method	to produce good approximation of customer demand	by finding the most appropriate model	Early March 2006	MPC	MPC analyst
Working standard	to work properly	by following ISO 9000 requirement	Early march 2006	MPC	MPC section head
Sales plan	the current sales plan was not working due to product proliferation is not considered	building communication between CR and MPC	Early March 2006	CR and MPC	CR and MPC section heads
Practices and knowledge	to empower MPC worker in making forecasting	training and discussing	Early March 2006	MPC	MPC section head

Table 2 reveals the action plan of the stakeholders in the company. For instance, the sales plan must be communicated between Customer Relations (CR) and Marketing Planning and Control (MPC). The results of these action plans are then used in the customer satisfaction result in 2006, as shown in Section 3.3.3.

Customer satisfaction result 2006

After getting the result of the customer satisfaction survey, the data were plotted on the graph. Figure 6 presents the customer satisfaction rate, showing customer perceptions of product quality and service. This assessment compares the company's performance against that of its competitors (local and foreign).

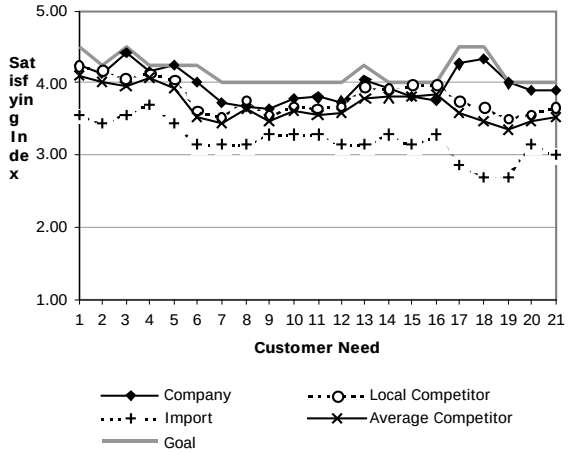


Figure 6a: Results of customer satisfaction survey: Product quality.

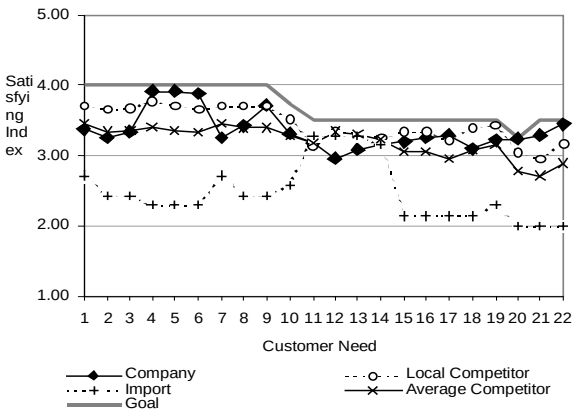


Figure 6b: Results of customer satisfaction survey: Service quality.

The satisfaction index measures customer satisfaction in relation to requirements, as in Table 1. During 2006, 200 questionnaires were distributed to customers in order to observe their satisfaction with the items in Table 1. The company used the same Likert scale, ranging between very weak, weak, fairly strong, strong and very strong.

The results of the above figures may be summarized as follows:

1. Customers give a high degree of importance to product quality (3,2-4,5). The results imply that the company has been a market leader in terms of product quality and needs only to keep its positioning strategy and continuously improve its quality to attain its goal.
2. Customers give a moderate level of importance to service quality (3,0-3,9). The results imply, however, that the company has been a market follower in terms of service quality and needs to continuously improve its service quality to attain its goal.
3. Comparing the organization's performance with that of its competitors suggests that:

- Generally, the company's performance in product quality is better than its competitors.
- In most areas the company's performance in terms of service is inferior to its competitors.

4. The benchmarking of performance between the case under review and other food manufacturing companies in the world shows that serious work must be done to improve its production process and cleaning standards. In most of these areas, the company lags behind its competitors. This means that a better system must be implemented and also more professional employees should be recruited to bring the company's flour mills to the benchmarked level.

This benchmarking encourages the company to apply TQM so as to improve its product and service quality. For the first action plan, the company prioritizes its top ten attributes as the most important attributes, as follows

- Product quality side: Quality Control/Quality Assurance, Implementation of Quality and Food Safety International Standard, Wheat provider, Packaging material, added iron & vitamins, Health certification.
- Services side: Training Centre Technical Representative, Promotion activities, sales & distribution, Depots, Hotline service, Quality Control/ Quality Assurance, Payment system, Production code and Research & Development.

The reason for focusing on the top ten priorities is that the company wants to cover improvement in terms of the importance of these attributes to the customers at the point of sale and also give the most benefit to the company.

ANALYSIS AND MEASURING THE SUCCESS OF TQM

Designing and implementing an effective performance measurement system in the TQM context is, however, not a straightforward task and numerous authors have tried to provide guidelines and recommendations for firms adopting TQM. Kaplan and Norton (2001) state that an effective performance measurement system should provide timely, accurate feedback on the efficiency and effectiveness of operations. To be effective, a performance measurement system must therefore be based on the drivers of organizational success, which in the context of TQM include, among other things, customer satisfaction and social impact (Claver et al., 2003). The long-term goals of TQM performance measurement should include the continuous improvement of performance and maximization of customer satisfaction by adapting to change in customer requirements and the general business environment. The implementation of performance measurement in the context of TQM depends on many factors: leadership, quality planning, specialized training, supplier management, process management and continuous improvement, as well as organizational learning (Claver et al., 2003).

Despite the vast amount of research on performance measurement in the TQM context, there is still a lack of empirical research seeking to discover what performance measures are actually being used by those who adopt TQM and how appropriate these companies find them. In order to bridge the gap properly, this study investigates the extent of use and appropriateness of the performance measurement systems applied in the TQM context within the domains of customer satisfaction and quality of products and services in food manufacturing SMEs.

The company measures the performance indicators to observe TQM's effectiveness from 2006 to 2008, as shown in Table 3 below. The second QFD is then developed to measure the effectiveness of the TQM programmes. The benchmarking results of the previous QFD (see Figure 6 a root cause analysis) are then used as inputs to the technical correlations of the new QFD. A new customer survey is then conducted in 2008 in order to measure the fitness of the TQM programme to the new customer survey results. The results are then summarized as shown in Figure 7.

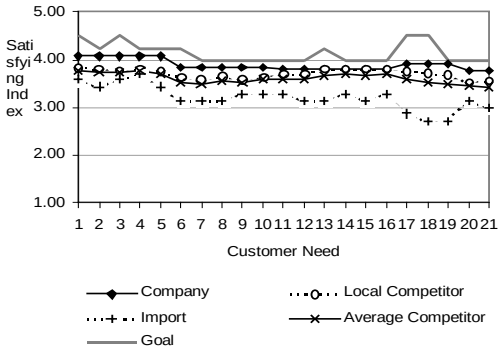


Figure 7a: Results of customer satisfaction survey: Product quality.

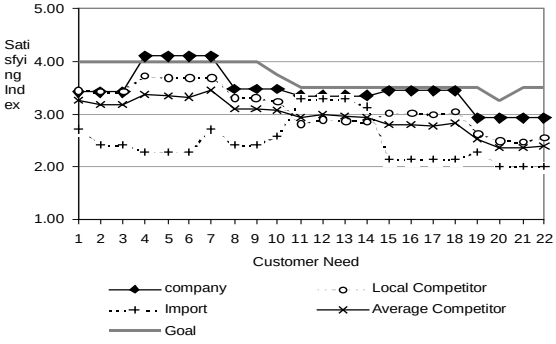


Figure 7b: Results of customer satisfaction survey: Service quality.

The Improvement Ratio for product quality has a lower value (1- 1.097), its mean company performance being very close to customer needs. Incidentally, the company needs to be serious about its performance in the matter of its services, because the improvement ratio for service is high in value.

Comparison of the company's performance in 2006 and in 2008 (Product Quality)

Based on the above comparison of customer satisfaction, the customer satisfaction index for product quality in 2008 is in general lower than in 2006. Some aspects, which have been successfully improved can be seen in point 7 (brown spots), 8 (product clumping), 9 (insects), 10 (unpleasant odour) and 16 (weight accuracy), but it has not yet reached its goal yet (check with Table 1). The company finally applied housekeeping and implemented good manufacturing practices for the food industry by considering that most of the unmet criteria fell under the heading of product cleanliness.

Comparison of the company's performance with that of its competitors in 2008 (Product Quality)

Generally, the company's performance was better than those of its competitors (whether for local or imported flour).

Comparison of company's performance in 2006 and in 2008 (Service Quality)

According to the above comparison of customer satisfaction, the customer satisfaction index for service quality in 2008 is generally higher than 2006, but it has not reached the designated goal in every component. Only 4 components succeeded as point 4 (Anytime product taking), 5 (Reachable station), 6 (Ease of ordering) and 7 (Delivery in place); other aspects, which need to be improved, are point: 9 (production code), 19 (discount), 20 (prize), 21 (rewards) and 22 (credit terms and payment period). The company finally improved their logistics networks by making contact with more autonomous distributors and attracting them by the offer of more rewards and quantity discounts.

Comparison of company's performance with that of its competitors in 2008 (Service Quality)

Generally, the company's performance is higher than those of its competitors (whether local or imported flour).

Table 3: Index growth of customer satisfaction with the company and its competitors between 2006 and 2008.

Flour Producer	**Product Quality**			**Service Quality**		
	2008	2006	Growth	2008	2006	Growth
Company	3.87	3.98	-2.71 %	3.46	3.35	3.29 %
Local Competitors	3.71	3.81	-2.79 %	3.12	3.45	-9.41 %
Foreign Competitors	3.21	3.21	0.00 %	2.47	2.47	0.00 %
Average Competitors	3.61	4.15	-2.31 %	2.96	3.20	-7.59 %

Table 3 shows that significant improvements were made in terms of company service quality (3, 29%). However, product quality went down, g. This reduction in product quality level is caused by the commitment of the local government to implementing the Hazard Analysis and Critical Control Point (HACCP) as a food safety standard. Thus this product quality reduction is not caused by inferior process performance. Indeed, the company has increased its product quality standard by adopting the HACCP standard.

Customer satisfaction index growth analysis

Referring to Table 3 above, the index growth of customer satisfaction indicates a shifting of customers' perception of the flour produced by the company and by its competitors. A shift in customer perception is shown in the decline of the customer satisfaction index of product quality against a rise in the customer satisfaction index of service. In this case, it is revealed

in the perception of quality in the flour produced by the company. This may have been influenced by any of the following factors:

- Management commitment and policy,
- Continual improvement in technology and innovation
- Management of the supply chain from supplier to end user

CONCLUSION

Most successful manufacturing companies have embraced TQM and realized its invaluable contribution. This acknowledges the importance of TQM as an effective method of achieving excellence in manufacturing, which cannot be denied. Embracing the concept of manufacturing excellence is considered a route to becoming the best manufacturer of a certain product. It refers to the ultimate goal of achieving the best manufacturing capabilities or being best-in-class in performance. Because of the pervasive use and reliance on business systems today, effective TQM strategy is much in demand to deal with all the activities of a company. The present paper brings together information from diverse sources to offer a common starting point and information base for quality assurance professionals. A comparison of customer satisfaction with product and service can help these professionals to apply this alternative method and tailor it to or integrate it in specific applications.

A continuous QFD needs to be deployed at the lowest level of operations. In addition, in order to make TQM work efficiently, companies need to build a corporate culture to replace continuous QFD. When this is applied, it should encourage people to apply the quality improvement programme more proactively. This shortens the life cycle of analysis between one QFD and another and the company becomes more competitive due to the increasing speed of its innovations.

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B1 – Knowledge Management

B1.1 **A study of the organizational knowledge-transfer within the industry to initatate the model for the govermance**
Chacrit Sritong

B1.2 **Evolution of knowledge management in technological era: A tailor made methodology to enterprise 2.0**
Elena Alberghini

B1.3 **Knowledge creation for competitive advantages using dialectic model: A study on Islamic bank of Thailand**
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B1.4 **Knowledge management and project management**
Radosław Paliszkiewicz

B1.5 **Synergetic effects of product training and training transfer factors on marketing mix – Case study on domestic appliance industry**
Dr. Peter Meža

A STUDY OF THE ORGANIZATIONAL KNOWLEDGE-TRANSFER WITHIN THE INDUSTRY TO INITATATE THE MODEL FOR THE GOVERMANCE

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ABSTRACT

This study aims to study the knowledge transfer pattern of success organizations in performing knowledge management in Thailand and construct the conceptual model of knowledge transfer in order to be the prototype for governance academic institute. Moreover, the pattern and procedure of knowledge transfer will be provided for governance academic institute in Thailand to be the success organization in performing knowledge management. The qualitative method was employed in this study. The in-depth interview was used as the data collecting tool. The sample of this study was four entrepreneurs from the medium and large companies where perform and succeed in the knowledge management. The topics of interview were focused on the success factors and patterns of knowledge transfer of entrepreneur in industrial sector. The results showed that the success key of knowledge transfer consisted of five factors which included the leadership perspective of each company in transferring knowledge, the use of information technology in transferring the knowledge, the team work system in knowledge transfer, knowledge transfer by experiential learning, and knowledge transfer by training system.

Keywords Knowledge Transfer, Key Success Knowledge Transfer

INTRODUCTION

The knowledge management (KM) in Thailand stands up to the serious problems about missing some of individual knowledge that accumulated during work until retire or leave completely that should be affected to the organizational operations. Many researchers attempt to solve this solution and find out the right method for capture that tacit knowledge from individual and additional into organizational system and examine the diffusion model for transfer tacit knowledge to the whole organization throughout building the learning organization (LO) and knowledge management simultaneously. Kumar et al. (2006) described the definition of knowledge management as: “Knowledge management is an umbrella term for making more efficient use of the human knowledge that exists within an organization It is essentially an industry trying to distinguish itself with specialized groupware and business intelligence (BI) products that offer a wide range of solutions. The major focus of knowledge management is to identify and gather content from documents,

reports and other sources and to be able to search that content for meaningful relationships."

It is necessary that the organization must manage the internal knowledge and convert into the own system and encourage the staffs' learning all the time. Managing the knowledge under non-learning atmosphere always failure immediately, beside the management of learning organization is more complicate than human development; education or training because of the consequence in process that have to implement after the people have the knowledge and skills enough. How organization convince those people for willing to transfer and share their knowledge to others. The last activity, organization should find the technique to keep that special knowledge and combine it into the organizational system and assessable effectively. There are many agencies from the governance and private sectors try to built the own model of knowledge management align their context and organizational culture that causes for top manager seeking the strategic to elicit the individual knowledge and share to the colleagues. Training is not the best way to transfer knowledge, majority obstruction of knowledge management is behavior "Possessive" prevent others from getting the knowledge and culture "Reject the personalization" should be the weak point of Thailand knowledge management and lead to underachievement.

Recently, the knowledge management in industry sector is strong and widely promoted focuses on human liken to human capital. The leading companies in KM importantly apply information technology (IT) like the main tools to build the model of knowledge transfer such as Siam Cement Group (SCG) in private sector and the Electricity Generating Authority of Thailand (EGAT) in government sector.

The study use comparison method to benchmark the process of management knowledge between academic institute and top company which are successful in KM from industry sector, capturing the knowledge from both initiate by staff and expertise into "Content or e-Library" found that only capturing is not enough for emerge the real succeed but also the right pattern of knowledge transfer to share within organization.

The result of the study found that most academic institute in Thailand tend to failure cycle in KM and knowledge transfer, especially governance academic institute that measure knowledge from "number of information that kept in knowledge base" without design process of learning organization i.e. building the curious environment to know, encouraging the "people" to share and emphasize the knowledge transfer to be clear, systematic and formal procedure.

The purpose of this paper is aim to explore the model of knowledge transfer in successful KM, case study of Thailand. Additional purpose is to initiate the pilot model for governance academic institute which they can apply this model, procedure and knowledge transfer system to get the explicit knowledge and encourage their KM successful.

OBJECTIVE OF THIS STUDY

The purposes of the study were;

1. To find out the knowledge transfer model in industry
2. To develop the knowledge transfer-pilot model for governance academic institute

SCOPE OF THIS STUDY

This study is quality research and collected data via in-dept interview technique: a simple of 4 entrepreneurs were undertaken regarding people who expert in the field of knowledge management and had worked at the successful company , in industry scale which are emphasized in medium and large enterprise defined in the classification from Thailand Office of Small and Medium Enterprises Promotion; wealth of asset or number of employees and they classify the type of business into production, service and trade.

The highlight of this study is to concentrate the successful factors and model of knowledge transfer for entrepreneur in industry scale which emphasizes the knowledge transfer model towards the successful goal.

BENEFIT OR VALUE OF THIS STUDY

This study shows the factors important to organizational knowledge transfer in industry that medium and large scale. This result guide to development the core competency of the government agency which need to build pattern up and pursuit knowledge transfer or for firms which interest to build knowledge transfer within organization and reinforce the special skill for knowledge transfer process i.e. seeking the knowledge and utilizing this tool for encourage the effective knowledge transfer.

CONCEPTUAL FRAMEWORK

The researcher of this study is to highlight the knowledge transfer model in knowledge management process.

The human understanding can be defined in four terms of knowledge level that differentiated and consequence; data, information, knowledge and wisdom, from apply processes of the consideration, separation, syntheses and analysis. The knowledge management process consists of 3 main compositions; knowledge generation, knowledge organization and storage and knowledge transfer (Awad and Ghaziri, 2004) and additional, the knowledge application (Natarajan and Shekhav, 2000) which is the most difficult step, then Laodon and Laodon (2006) have exhibited the diffusion of knowledge is shown in figure 1.

Figure 1: Knowledge management process (Laodon and Laodon, 2006).

The four steps of knowledge management are:

Step 1: Knowledge acquisition: get the knowledge from the variety sources i.e. both inside and outside the firm via knowledge conversion following the SECI model (Nonaka and Takeuchi, 1995)

Step 2: Knowledge storage: keep, syntheses, digest, collection and organize knowledge

Step 3: Knowledge disseminations: distribute the kept knowledge

Step 4: Knowledge application: utilization, apply the knowledge right

Along with the whole process need the right technology that suitable with the organization as the tools for communication and collaboration; knowledge exchange, knowledge transfer and including any activities which right tools i.e. community of practice (COP).

The researcher applies the knowledge management model (Laodon and Laodon, 2006) for the pilot study and there are the procedures as below.

RESEARCH PROCEDURE

Since the objective of the study was to explore and develop the knowledge transfer for governance academic institute. This study is qualitative research method and focus on seeking the important factors in knowledge transfer process from industry scale which has the steps as follows:

1. The study targeted the population who is the entrepreneur or top manager in industry scale who are expert or work in knowledge management field, successful business and work in medium and large firm as the definitions following the Thailand Small and Medium Enterprises Promotion that classify by wealth of asset, number of employees and classify type of business i.e. production, service, trade. A five of them were chosen by purposive sampling.
2. Methodology of data collection by in-dept interview with semi-structure that formulated from review literature.
3. Data analysis is the descriptive analysis by assesses the general information of entrepreneur then arranges the interviewed data and analysis linked the objectives, issues and related literatures.

RESULTS AND DISCUSSION

Case study of Firm A

The characteristic of firm A's work-style is learning center both academic and vocational train institute and join together between Thailand and Japan institute, formed organizational chart liken to mixed-structure association. There are three types of services i.e. Education and training, languages schools and calibration those are effected to the design of the knowledge transfer model that directly towards to the people in firm A who are smart expert and professional in variety issues, Firm expect that all people will transfer the tactic knowledge to explicit knowledge by sharing system. Firm A's knowledge transfer model has the characteristics as follow;

1. Apply the information technology (IT)system to support the knowledge transfer process via the variety tools as follows;
   1.1 E-learning Tools
   1.2 Electronic Yellow Pages
   1.3 E-mail
   1.4 Groupware
   1.5 Internet
   1.6 Intranet
2. Apply meeting system to exchange knowledge by build the environment which will be promoted the learning organization and encourages the staff to transfer or to participate in the knowledge transfer process such as set up the knowledge forum, mentoring program for new staff or new assignment or new project, and peer assistance system.
3. Child center management system that focus on the learner, the emphasize of firm A is education and training program aim to transfer knowledge. Therefore, the main strategic is concern the learner, this issue effects to get and gather knowledge and ability to transfer the knowledge requirement that seeking from variety sources i.e. inside and outside the classroom.
4. Teamwork system makes colleague received knowledge from multi-transfer method i.e. sharing from whom work together
5. Small group activity is one of exchange the ideas aim to solve the problem together in small group member to share between working
6. Job change management such as change the job description, rotation, exchange staff.

The conclusion of firm A's knowledge transfer model indicated that firm A did not emphasize on IT supporting system and built the environment for encourage learning but focus on people processed by self-learning with teamwork system and mentoring system. The key successful is leadership, the leader of organization deploy the policy and give priority to knowledge transfer process to staff and clearly identity mission and setting strategic in knowledge transfer.

Case study of Firm B

Firm B is a big manufacturer which product hard disk drive, such as Top Cover, Ramp, Crash stop, Latch and automobile electronic parts, was establish in 2001 by Japanese capitalist in Thailand and resisted 360 million bath.

Since the mission of firm B was set going to the world-class company in electronic parts with high accuracy made firm determined the procedure have to focus on how to produce with high accuracy. It is necessary to built learning organization (LO) for force the people know how-to and gain their ability. The significant supported tools is knowledge transfer model.

Firm B built thirteen patterns for the knowledge transfer model that align the firm's mission were;

1. Training

1.1 Team Work Training: Firm set up the activities for employee in military camp and trained by soldiers. This style aim to keep disciplinary regulations and teamwork.

1.2 IT Training: Firm join with Microsoft by educating and training by Microsoft to meet Microsoft conditions and will be certified by Microsoft.

1.3 Language Training: Firm emphasize in English and Japanese, and give more incentive to whom that has this skill.

2. Working Environment

2.1 Firm apply the concept of quality tools i.e. 5S to run the business beyond the steady state condition of "Cleanliness is The Heart of Our Business"

3. Communication

3.1 Firm use multi-channel for communication within organization and publish relationship (PR) via the variety tools such as electronic board, whiteboard, curriculum, magazine, brochure and radio

4. Activity

4.1 Core activities that all people must be done and kept as the rule of conduct such as 5S, total prevention management (TPM), PIZ.

5. SGA : Small Group Activity

The SGA of firm B is shown as the figure 2

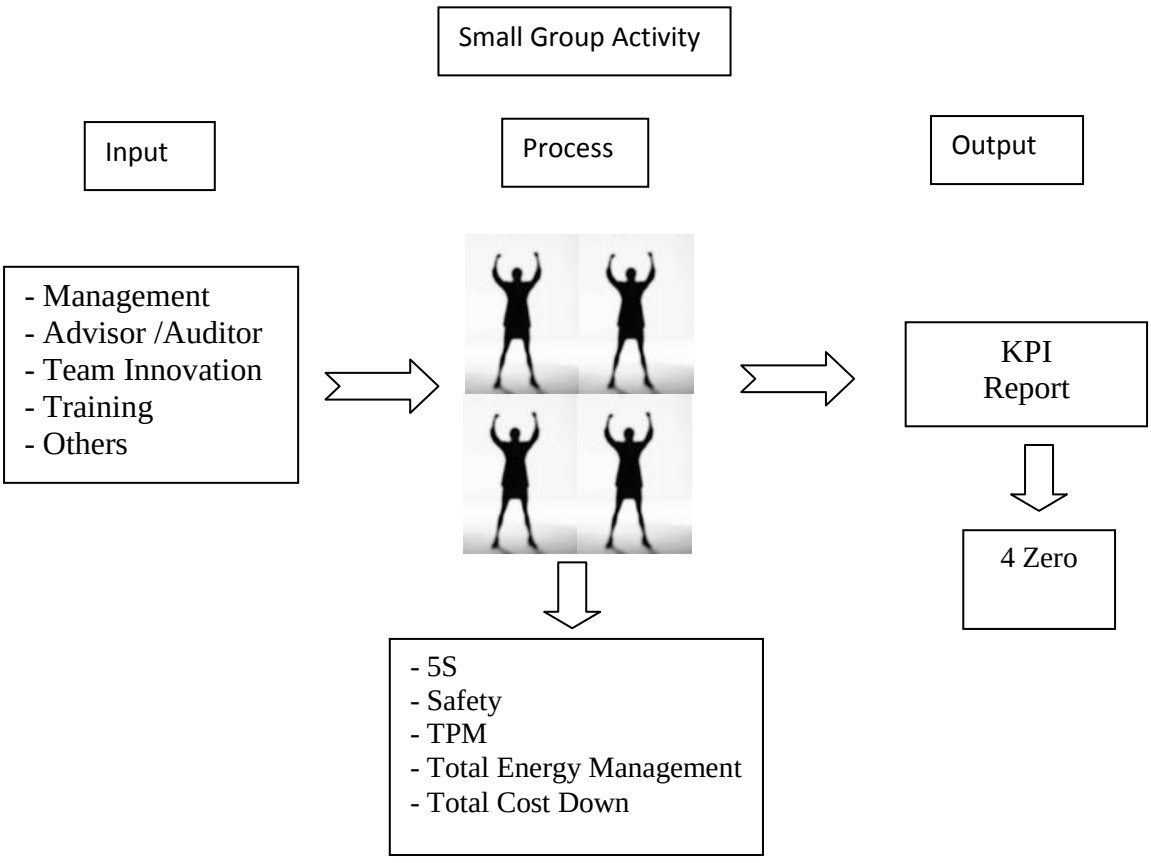

Figure 2: Firm B's Small Group Activity (Source: Contact the author.)

There are any activities and competitions between SGA, each group should be always prepare itself and meeting for setting their action plan to challenge winner and get the rewards and motivation.

6. Master Program
   6.1 Master Program is providing the priority activities for competitiveness within organization for building the learning organization and encouraging the people curiously to know and learn by themselves.
7. International Standard
   7.1 Firm want people understand the quality via the procedure of internal standard such as ISO 9001 and ISO 14000 which firm required and always push them to get it.
8. Customer Requirement
   8.1 Firm underline the customer feedback and always communicate to customer and get their comments via multi-channel such as call center, company webpage.
9. Problem & Solving
   9.1 Firm focus on the special R&D which solving the problems from production process or product.
10. Outside Visit
    10.1 Firm organize knowledge transfer technique broadly via multi-tools such as field trip outside firm or aboard and benchmarking
11. Technical Knowledge
    11.1 Firm highlight technical knowledge among production line via quality control activities i.e. Quality Control Cycle (QCC), Kaizan suggestion System (KSS) which is the sharing tool among the team.
12. Internal Trainer
    12.1 Firm will survey topics from staff and create the activity accord with their requested.
13. International Audit
    13.1 Due to this firm was invested by Japanese company which has their own standard and implemented in any places, firm B must have quality policy to control the quality meet the Japanese standards.

The conclusion of firm B's knowledge transfer model is shown that the background of firm B was invested by Japanese company lead the organizational culture to emphasize on staff's learning process within organization. Firm B has launched policy and strategic for building the learning underline the people via teamwork system by formed a big and small group that they can do whatever together such as learn, share, transfer something maybe sources from internal group or cross-boarder. Moreover, firm apply IT supporting system to knowledge transfer tools. Additional, the knowledge transfer process via learning by doing under the rule of quality assurance system in each product standard and transfer knowledge from linking among standard of each part.

Case study of Firm C

Firm C is the multinational business consultant which has head quarter in New York and 83 branches around the world, and there are 5 offices in South-East Asia. Firm C is outstanding in knowledge management and being a world-class leader in knowledge management.

Corporate' mission statements are "To build a grate firm that will attract, develop, excite, and retain exceptional people", and "To help our clients make distinctive, lasting, and substantial improvement in their performance"

Firm C is big and a top range in management consulting firms in the world, its business is to delivery the advanced solution to enhance client. There are the enormous capability people from diversified places on over the world transfer the numerous solutions and share the experience together, but it is not easy because of the site and locations. Firm C was built the organizational culture as the tools for seeking the knowledge from other people within organization, additional the mind of transfer the tactic knowledge diffuse to others in different places. The state of art to build the organization culture those were:

1. Value

The state condition of organization is important to employee that is approach the people is the wealth asset of organization.

2. Teamwork

There are separate the level of authority to access the knowledge significant into 3 levels; partner, part-time and steering group that were;

- Partner is the client who had ever worked and supports each other.
- Part-time is the temporary team for solving the problem.
- Steering group is consulting group who screen and contribute the knowledge in the database.

Knowledge management technology and Collaboration Tools for sharing experience and information should be supported by information technology (IT) system, those were;

1. Explicit knowledge sharing system
    - Intranet
    - Publish i.e. Knowledge map; if topic of petroleum required, seeking at petroleum catalog which there are many indeed sub-topics or search with customize search style.
2. Community of Practice (COP)
    - Practice network
    - Internal communication: Mckipedia, Blogs, forums
3. Center of Excellence (COE)
    - Industry practice expert
    - Function practice expert
    - Special initiatives
    - First alert

To evaluate knowledge transfer of Firm C by evaluating from follow up the understanding of monitoring in order to stimulate of sharing knowledge system or create new knowledge

such as setting the number of time and minimum time used the accessing knowledge by working system.

The conclusion of Firm C, that is the big multinational business consultant around the world as well as high quality of staff. All staff came from many countries which had different cultures so company has target of exchange knowledge management among staff. That why company make new culture as the tool for knowledge management. By the specific on person and create teamwork system in order to have knowledge sharing system by connecting of each staff in different countries. Company has emphasized on IT which is the tool of connecting knowledge management and transfer knowledge management of company.

Case study of Firm D

Firm D is the small and medium enterprise (SMEs) in which concern the research and development (R&D) for industrial of aquaculture, cattle, pet and agriculture. Currently firm start to research and development in kind of the cosmetics, customer goods and health care products. In according to firm has studying about applied research and experimental development in order to create innovation and making the economic valve for organization. In case, firm need to collect data arrangement and keep all data in appropriate system which can reduce loss information of organization as most as possible.

To operate and have strategies of firm D for building learning organization of this company by using knowledge to create knowledge organization. The process and model of transfer knowledge of firm D were;

1. Firm emphasis on the developing the employee by use knowledge widely and open mind for creative and operation themselves.
2. Firm give the knowledge opportunities for staff to training or seminar inside-and-outside the organization.
3. Top manager have deploy the policy and motivate for the staff making the creative project for organizational development.
4. Company has to install the data base server and intranet system of organization for all staff sharing knowledge.
5. Sharing the knowledge from job skills among the department by a monthly meeting.

Idea of operating's Firm D

- Personal level: the executive managers give the knowledge opportunities and challenge for the staff to enlarge themselves by participating the seminar from outside. In order to apply the right knowledge and utilization it in the organization as well as support all staff for new project at organization.

- Group level: the top managers have deploy the policy of "small group activities" for staff every week, about 2 hours. Let staff in same department t or other department share the ideas of organizational development front to the top managers such as the staff in academic department initiated and has presented the course of training the product's qualification.

Sale manager offer negotiation project training, accounting and technology department offer ERP: Enterprise project for minimizing risk, and additional, have contest for good project and stimulated by reward of creative project.

Structure

Organizational

Organizational structure has flexible and flat chain of command for adjust to the dynamic of the knowledge management of company as well as compatible with changing of knowledge.

Job

The characteristics of working as teamwork and able to work with cross-functional management, the people can rotate job or change the position in order to transfer knowledge among staff during working together.

Technology

Install the infrastructure in organization for basic knowledge such as the data base server and system for able to access knowledge easier.

The conclusion of Firm D as industrial company as kind business of research and development of aquaculture, cattle, pet and agriculture. Furthermore, company will product in line of the cosmetics, customer goods and health care products. Company need to depend on knowledge system in order to competitive with the foreign company by using company as knowledge organization to create model of knowledge.

Company emphasis on staff to develop knowledge by themselves and present as reality project. To train staffs share idea and how to solve problem. Moreover, company aim to work as teamwork for sharing idea and knowledge transfer.

CONCLUSION

The pattern of knowledge transfer of selected company was link with the knowledge disseminators of Laodon and London (2006). This can be concluded as shown below;

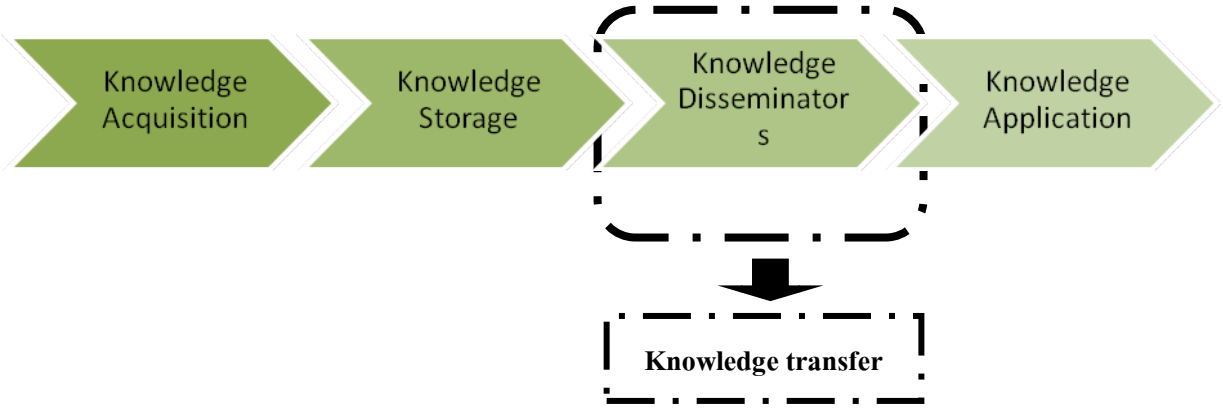

Figure 3: Knowledge management process (Laodon and Laodon , 2006) Focus on Knowledge Disseminator.

The step of knowledge transfer of each company was in the third step of knowledge management (Laodon and Laodon, 2006) which was the knowledge disseminator step. Moreover, this step was the “disseminate and transfer knowledge”. In this study, each company has their own strategy of knowledge disseminator as shown in Table 1.

Table 1: Key Success Knowledge Transfer case study of various companies.

Company A	Company B	Company C	Company D
Supporter	Supporter	Supporter	Supporter
IT System	Training	Culture creator	Education development of staff by experiential learning
Knowledge Sharing system with modified atmosphere	Working Environment	Team working system	Training Attended the seminar outside the company
Company A	**Company B**	**Company C**	**Company D**
Student base learning	Communication	IT System	IT System
Team working system	Activity	Explicit knowledge sharing system	Data Base Server and Intranet networking
Small-Group Activity	SGA : Small Group Activity	Community of Practice (CoP)	Project meeting
Rotation of Work	Master Program	Center of Excellence (COE)	Team working system
	International Standard		
	Customer Requirement		
	Problem & Solving		
	Outside Visit		
	Technical Knowledge		
	Internal Trainer		
	International Audit		

From Table 1, can be summarized the successful factors of Key Success Knowledge Transfer as below

1. The company leadership always focused on knowledge transfer
2. Knowledge transfer by the used of IT tool
3. Knowledge transfer by team working system
4. Knowledge transfer by experiential learning
5. Knowledge transfer by training system

From the summarized of Knowledge Transfer can identified that the importance factor effected to success of knowledge transfer comprise of 5 main topics and can be use as a conceptual model (Figure 4)

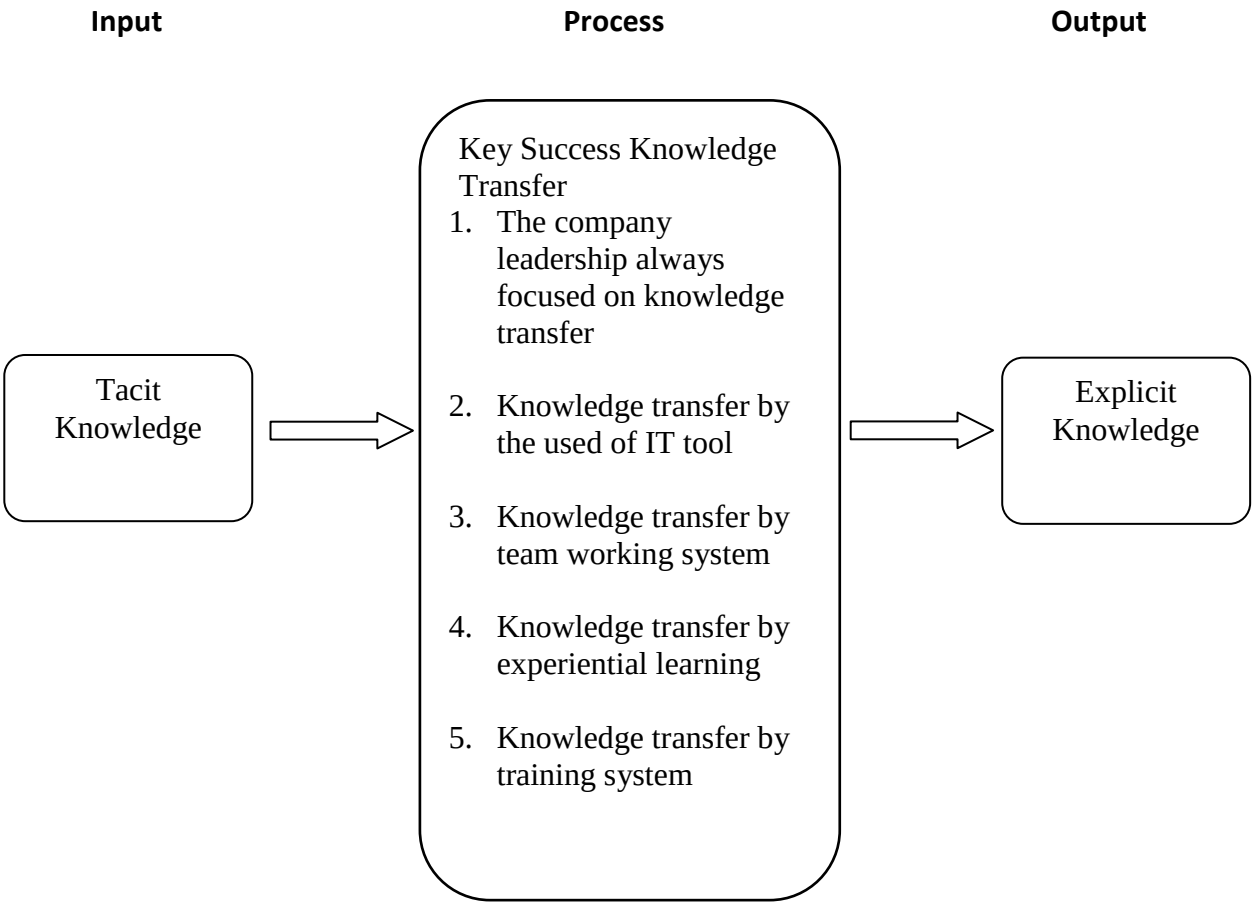

Figure 4: Conceptual Model of Knowledge Transfer.

From the conceptual model of knowledge transfer (Fig) can be finalized the key success knowledge transfer which is use as guideline for education and government sectors knowledge transferring, cause of, at present both sectors not yet success in KM to learning organization.

FURTHER RESEARCH

From the research found that Key Success Knowledge Transfer consists of 5 items:

1. The company leadership always focused on knowledge transfer
2. Knowledge transfer by the used of IT tool
3. Knowledge transfer by team working system
4. Knowledge transfer by experiential learning
5. Knowledge transfer by training system

This Key Success Knowledge Transfer has use for successful private company. The research tend, need the Key Success Knowledge Transfer to implement with the education sector to

proof that the Conceptual Model of Knowledge Transfer can be used with the education sector or not.

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EVOLUTION OF KNOWLEDGE MANAGEMENT IN TECHNOLOGICAL ERA: A TAILOR MADE METHODOLOGY TO ENTERPRISE 2.0

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ABSTRACT

New technology environments provide a simpler way to manage knowledge. Social technologies are becoming the preferred method of communication of new generations and communication styles are evolving into a more collaborative approach.

Effective knowledge sharing depends on several factors like mentality, technology availability and detectable personal advantage. The advent of the enterprise 2.0 phenomenon offers new opportunities to implement knowledge management, but a structured approach is needed to fulfill its vast potential.

This study presents a methodology for the application of social technologies to provide companies with an implicit knowledge real time map. The innovation elements of the methodology are given by the deep analysis of criticalities, needs, behaviors, perceptions and trends, helpful to continuously improve the application.

The methodology consists of three key elements which are analyzed in depth: the gap analysis, the toolkit selection and the action plan. Through these components this approach allows to effectively capture users' perceptions and behaviors adapting the tools to the context specificity.

This paper aims to take up the challenges of examining the issues of knowledge sharing and transfer. It presents a first empirical application of this approach in Eni, an integrated energy company, active in more than seventy countries all over the world. The analysis includes the choice of indicators which help to monitor users' trends and engagement.

Keywords: social technology, enterprise 2.0, knowledge management, knowledge sharing.

INTRODUCTION

New technology backgrounds are transforming the way knowledge is experienced (Norris et al., 2003). Moreover the standards of today's fast and hyperactive world are far from the

context of the initial studies about KM. Traditional KM is characterized by a primarily top down approach and by specifying all contents structures in advance (Davenport, 2008). This approach is becoming not suitable anymore, even inside big companies with a consolidated culture (Leidner, et al. 2006). Today firms are very complex environments. Information technology has experienced many cycles of innovation, producing always more complex and integrated set of technologies to respond directly to business needs (Koplowitz, 2010). In spite of this, the huge quantity of documents produced daily can create innumerable silos of information. As a consequence knowledge capture and sharing can be too difficult and ineffective (Alberghini, et al., 2010).

The advent of the enterprise 2.0 phenomenon offers new opportunities to implement KM, but a structured approach is needed to fulfill its vast potential. The term "Enterprise 2.0" was first coined in 2006 by Andrew McAfee in an article about the use of emergent social software platforms within companies, or between companies and their partners or customers (McAfee, 2006). Even if there is still a debate about the relationship between Enterprise 2.0 and KM, applying web 2.0 technologies and emerging social behaviors can help to add greater interactivity into the KM environment. Social networking capabilities are providing vital information in a way that is adaptive and user-driven. Moreover new generations are used to dealing with social technologies, choosing them as their preferred method of communication with peers (De Gennaro, 2010).

This paper aims to take up the challenges of examining the issues of knowledge sharing and transfer in an energy company operating across all the world. More in detail, this study aims to provide with an applicative example of the structured approach which reckons with the context, people maturity level and KM purposes. The paper examines the steps of this approach, from the analysis of new needs to the application of social technologies. The methodology arises from the necessity to evaluate tools and the way to make use of them and the study present a set of analyses applied in Eni, an integrated energy company. Eni operates in the oil and gas, electricity generation and sale, petrochemicals, oilfield services construction and engineering industries. In these businesses it has a strong edge and leading international market position. Eni is active in 77 countries with a staff of about 78,400 employees.

At the beginning, the study concentrates on the modalities of the assessment phase, in which the target is represented by the deduction of new behaviors, perceptions and needs and by the evaluation of the lacks of the extant technology situation. The analysis is carried on through the observation of users trends, present technologies' availability and colleagues satisfaction surveys. The results allow to gain awareness of the internal fragmented environment and the rapidly evolving external landscape. Moreover the results represent a useful starting point to define the strategy to get the most from knowledge sharing and to guide the choice of indicators which help to monitor users' trends and engagement.

In this study the choice was oriented towards a social network in which everything was set up in a very modular way, in order to better follow employ needs to facilitate their job. Global networking sites bring people with common interest together increasing engagement. Choosing a technology target should be not enough to ensure a success. Old

generations tend to be skeptical about social technologies, so it is important to implement something very useful, in working terms, and that should become a habit and a necessity at work. For this reason a golden rule is monitoring the user engagement to nurture and build the community.

The paper is organized as follows. Section 2 provides a literature review about KM tools. Section 3 defines and analyses the methodology split into perception and qualitative/quantitative analyses. Section 4 describes the findings and includes guidelines about what to do and not to do depending on empirical data. Moreover, this Section presents a way to diagnose new demands to continuously improve the implemented system and achieve higher benefits. Section 5 describes the research implications and limitations. Finally, Section 6 highlights and summarizes the application of the methodology.

LITERATURE BACKGROUND

In work environments increasingly permeated by internet, KM tools are becoming an important mediator in the way knowledge is managed (Rao, 2005). Global organizations have invested heavily in KM programs in order to facilitate the transfer process of best practices, (Davenport and Prusak, 1999). They support the achievement of organization's strategic objectives (Hackett, 2000; Sveiby, 1995) and the nature of these programs differs from a technological view to a people view (Perrin, 2007). The power of KM is in allowing organization to explicitly enable and enhance the productivity of processes and to leverage their value for the group as well as for the individual (Ruggles, 1997).

KM theory is evolving to a more human orientation and new challenges of KM tool usage are emerging. One of the classic works in the field of computer-mediated workspaces address the "social information" (Brown and Duguid, 2000). Knowledge sharing enables people in virtual communities to access relevant knowledge (explicit or tacit) from broader scope of resources (Yang, Chen, 2007). The purpose of socialization combines both technological and personalization (Perrin et al. 2007).

The factors affecting sharing and transfer of knowledge in an organization concern the motivation for sharing (Kalling, 2003), the ability of the source to share (Foss and Pedersen, 2002), knowledge tacitness (Argote and Ingram, 2000; McEvily and Chakravarthy, 2002), and the ability of the recipient to accept knowledge (Dilek and Ulku, 2008). According to Wenger (1999), knowledge is often shared with the help of the technology. Now technology is even more powerful, easy and helpful, anyway, according to Malhotra (2005), there is nothing new in technology-induced change. Companies should never begin their transitions with pioneering technology, because to make good use of technology it is necessary to know which technologies are relevant (Malhotra, 2005). Management strategies need to shift from command and control to sense and respond (Rao, 2005). To confirm this theory, surveys conducted by analysts such as Forrester Research demonstrate that social technologies continue to grow popularity inside the enterprise, in particular wiki adoption is in the lead, followed by social networks.

The potential of Social Technologies

Social Technology is technology for social purposes or with a social basis. Social software encloses a range of software systems that allow users to interact and share data. In the last years online communities have been getting increasingly. At the same time, community members seem to rapidly lack loyalty, as they tend to use their community less over time (Bae and Jan, 2008). To survive and thrive, online communities must meet members' needs. People are more likely to participate in innovation initiatives that are well publicized and transparent (Koplowitz, 2010). From users' perspective social technologies increase the desire and the need of knowledge sharing. As a consequence, one of the most important tangible benefits inside an organization is the unlocking innovation. This kind of technologies has exploded into the business world, but they are still vastly misunderstood. Many organizations are either blocking their use, or simply experimenting the hypothetical benefits. It's a fact that organization are only recently starting to appreciate the full collection of capabilities that exist under the social technologies. Tools like Facebook, Twitter, and LinkedIn appeared with personal use, but recent surveys have demonstrated that inside an organization users employ social technologies to improve their job not just for personal matters (Forrester Reasearch, 2009).

Each day, more and more people are choosing social technologies as their preferred method of communication with peers. Just as email and instant messaging replaced the phone call, social technologies could have a similar effect in changing communication dynamics (De Gennaro, 2010).

In an always more hyperactive world, people can feel immediate benefits in connecting with the right peers, getting answers to questions and finding information. According with Forrester analysts as De Gennaro and Fenwick, there are key trends that will make the inclusion of social technology in the IT management tool set a necessity. These trends are the physical distance between and the entrance of Millennials into the workforce (De Gennaro, 2010). Telecommuting can strongly help to lower costs due to physical distance between teams. This strategy makes improved collaboration absolutely critical. For what concerns the Millennials, also known as the Millennial Generation (Generation Y), they are people born between 1980 and 2000. They are now entering the workplace. These new employees bring very different needs, experiences, and expectations to the job and often meet a seasoned workforce that has very different work styles (Schooley, 2009). Anyway, what Millennials want to support their work, such as flexible work schedules, social media tools, or a collaborative environment are work features that other employees can benefit from, too (Schooley, 2008). Web 2.0 tools allow people to ask questions, share ideas, and discover people skills regardless of the hierarchy. Such these tools help to break down organizational and cultural barriers such as time differences (Koplowitz and Owens, 2010).

THE TAILOR MADE METHODOLOGY

The methodology arises from the necessity to evaluate tools and the way to make use of them. It consists of three key elements which are analyzed in depth: *the gap analysis and*

monitoring, the toolkit selection and customization and finally *the action plan.* Through these components this approach allows to effectively capture users' perceptions and behaviors adapting the tools to the context specificity.

The research has been conducted within Eni, a multinational integrated energy company. This company was of particular interest because it is characterized by a consolidated culture, even if it operates all over the world and in many activities.

At the beginning the study concentrates on the gap analysis, with the target of detecting new behaviors, perceptions and needs and evaluating the lacks of the extant technology situation. To be always useful and to follow user needs, most of the time available tools need to be integrated, customized and adapted to the existing context. The results allow to gain awareness of the internal fragmented environment and the rapidly evolving external landscape. They guide the action plan, that must be carry out by exploiting the chosen tools, eventually after a customization. Moreover the results represent a useful starting point to define the strategy to get the most from knowledge sharing and to guide the choice of indicators which help to monitor users' trends and engagement.

It is extremely important planning future steps. The action plan must take into account people maturity level respect to current technologies and utilization expectations in the same way that a sailor always steers the course. A golden rule is that the approach should be gradual, especially in a consolidate context. In this case three phases were chosen: firstly *supporting individual needs*, then *improving the collaborative culture* and finally *enhancing the collective intelligence.* This study concerns mainly the first phase and put the basis for the others. This is a first long term approach. Of course the evolution of the context will bring an evolution of the approach itself.

Figure 1: The framework of the methodology.

Gap Analysis and monitoring

This phase consists of different kinds of analysis: perceptive, qualitative and quantitative analysis. These analyses permit to assess and monitor the current situation. Qualitative and quantitative analyses are strictly correlated in this study.

Perceptive analysis
To measure attitudes and perceptions about available technology a questionnaire based on Likert scales has been applied to a representative sample of 153 employees working in the information and communication technology (ICT) area. A Likert scale is a psychometric scale widely used in questionnaires and it was named after its inventor, psychologist Rensis Likert (1932).

In this survey of about 80 items, the individual was invited to define his attitude towards each statement by choosing among a number of four scores (“*strongly disagree, disagree, agree, strongly agree”*). In this way the choice method was forced since the middle option of "*neither agree nor disagree*" was not available. On the contrary the “*not sure/not applicable*” option was available.

The gap between users expectations and experience is analyzed through eight dimensions*: general perception of KM, knowledge creation and capitalization, diffusion, utilization, utility expectation, utility perception, tangibles, expectations respect to strategic objectives.*

The results emphasize on the need for collaboration and sharing experience. The following charts summarize the aggregate results about users’ perceptions. For what concerns the general perception, KM is seen as a way to share knowledge by the 66% of people and it is recognized a great importance in growth and change management. In this case results about KM importance are quite good. An interest aspect is that only 4% of people see KM as an IT tool.

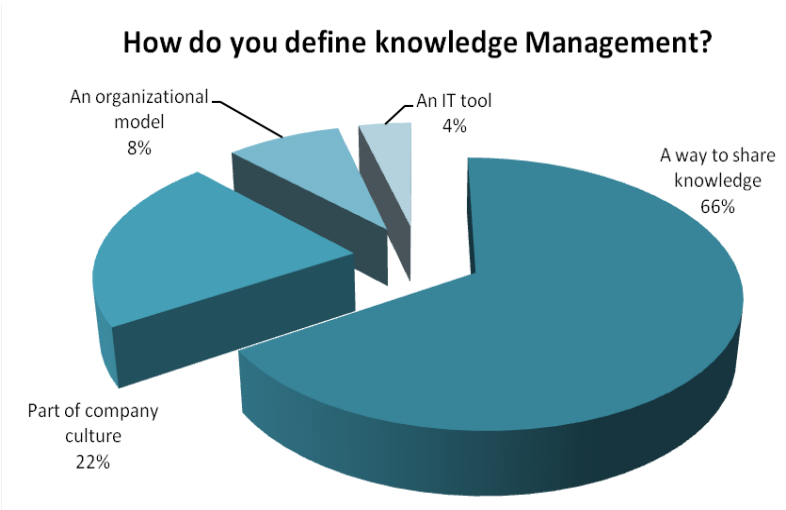

Figure 2: General perception of KM definition.

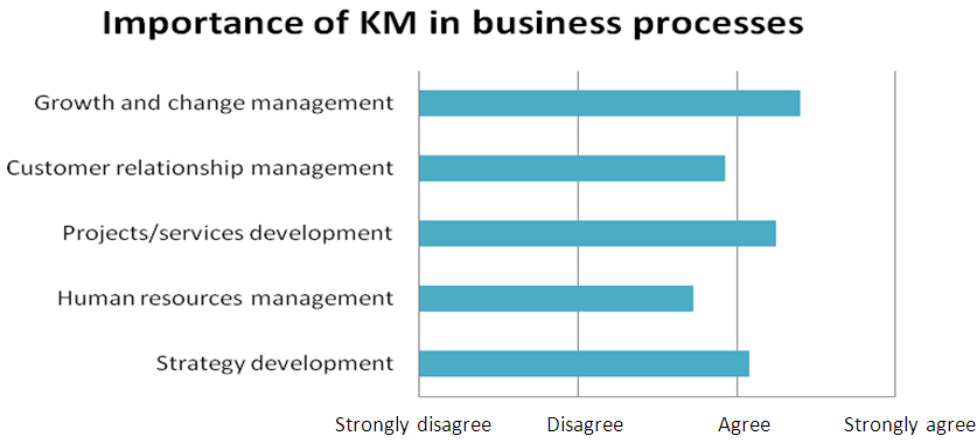

Figure 3: General perception of KM processes.

Sharing experience with other people and workshops have been recognized as the main sources of knowledge creation and capitalization. It is interesting to note that top down tools as collection of communications are in the bottom. It is the same also for what concern the knowledge diffusion dimension, in which results are very similar. In fact, sharing experience with other people and workshops have been recognized as well mostly relevant in favoring knowledge diffusion, while surveys and periodic communication are in the last positions.

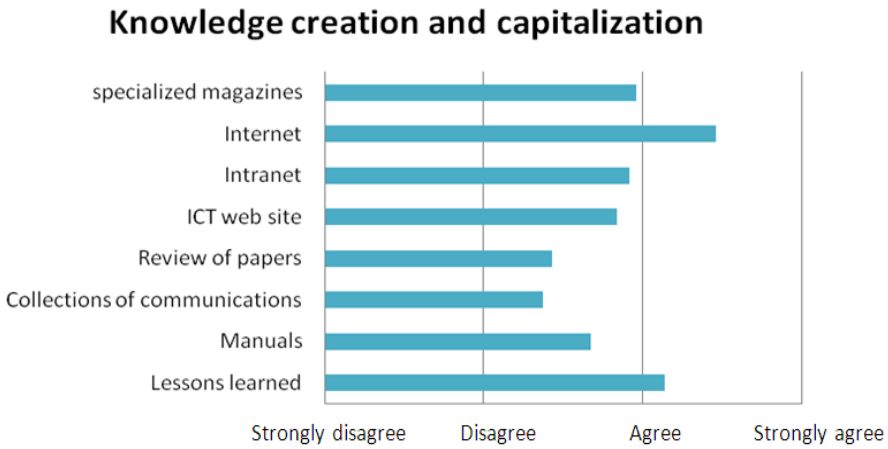

Figure 4: Knowledge Creation and Capitalization.

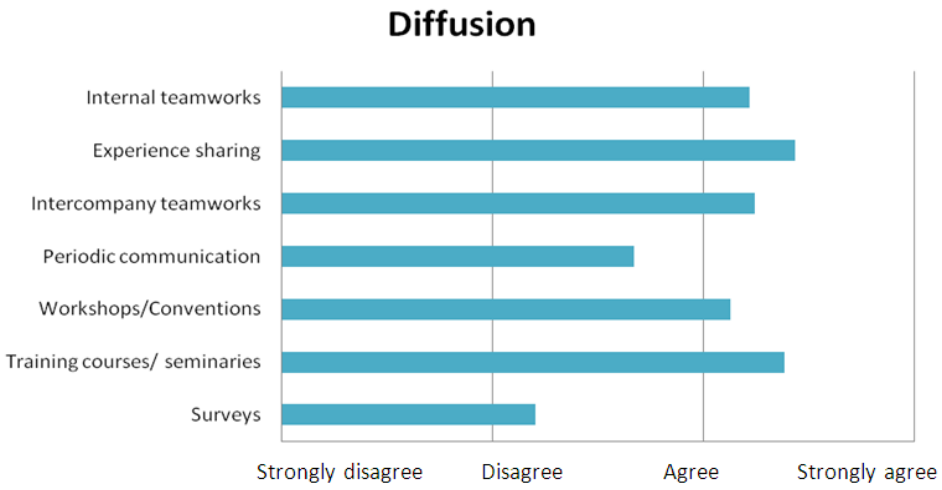

Figure 5: Knowledge Diffusion.

Internet, chat, instant messaging and email are the most used technologies. This result will be confirmed also by the quantitative analysis. People still use email as the preferred method of communications but there is an increasing interest in new technologies such as instant messaging and desktop sharing.

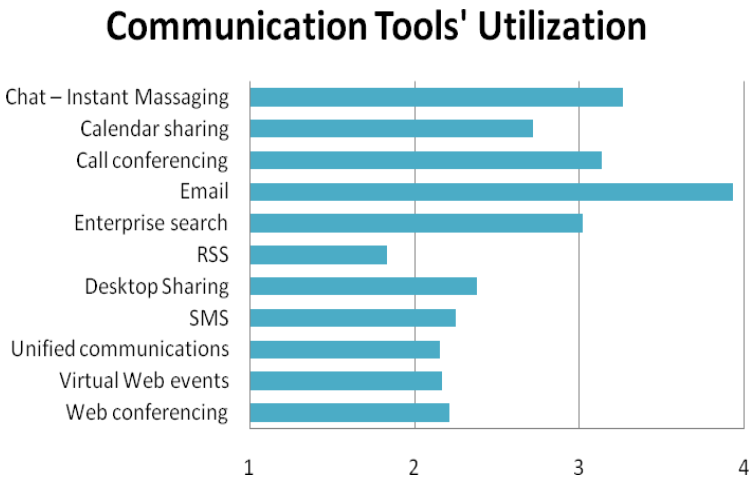

Figure 6: Tools' Utilization.

People were invited to choose on seven parameters about real perception and expectation of KM utility. These parameters are collaboration, competence, sharing knowledge, culture, change, content and connectivity. Expectations about KM utility are very high for all the aspects, in particular for collaboration and sharing knowledge. This means that people are definitely aware of KM importance. On the contrary the perceptions about what it is really available are quite low, especially for the competence map. Finding the right person with the right competence is one of the most important issue facing companies today, but it is not an easy task to be implemented. For what concern connectivity and collaboration they

are enough effectively perceived. The introduction of new collaboration tools provided an improvement in satisfaction.

Tangible activities confirm low perceptions, especially for the competence mapping and the easy accessing to lesson learned and process documentation. In fact, tangible activities are a sort of specification of some aspects of utility perceptions. The main expectations respect to strategic goals are about the improvement of the easiness of search and quality of information.

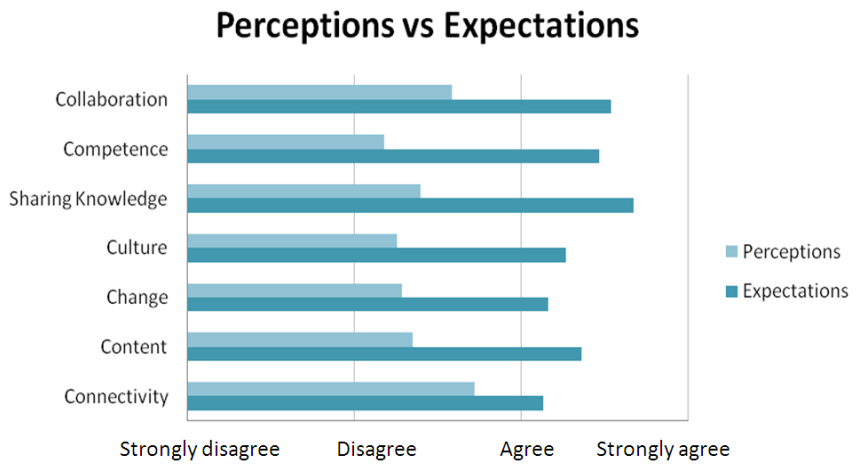

Figure 7: Utility Perceptions vs Utility Expectations.

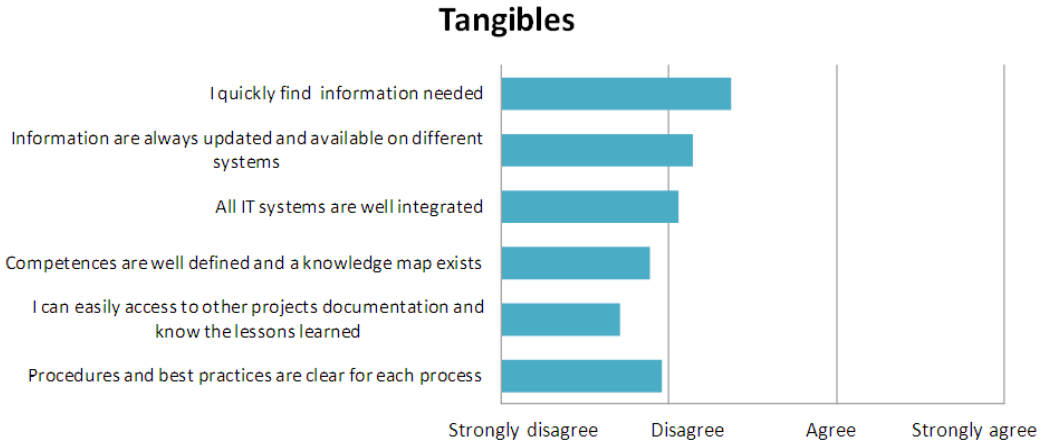

Figure 8: Tangible activities.

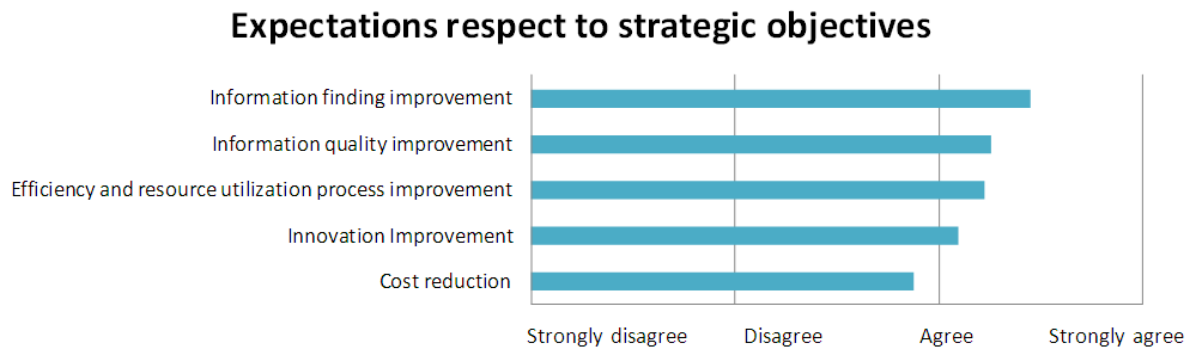

Figure 9: Expectations respect to strategic Goals.

Through the analysis of these results, it is possible to observe that people are ready to collaborate and that they strongly perceive the importance of sharing knowledge and collaborating. They have great expectations, because they feel the potential of new technologies and they are aware of innovation. They find some difficulty with the actual available systems, especially in mapping people skills, experiences and lesson learned.

Qualitative and quantitative analysis
Both qualitative and quantitative analyses contribute to corpus study. Current technologies and their real employment have been detected by specific tools able to collect and present information about user behavior on web sites as well as mobile devices running various operating systems. The quantitative analysis has been applied to a sample of 27.000 employees working in different Business Units. The quantitative results have been analyzed in a qualitative way to understand effective user needs.

Results revealed that users are constrained to employ many tools to reach their goals. Mostly they use IT tools to search people, find contacts and information about colleagues' positions and to communicate.

The introduction of new collaboration tools demonstrates a growing trend of utilization. The following chart shows utilization statistics concerning principal basic intranet tools.

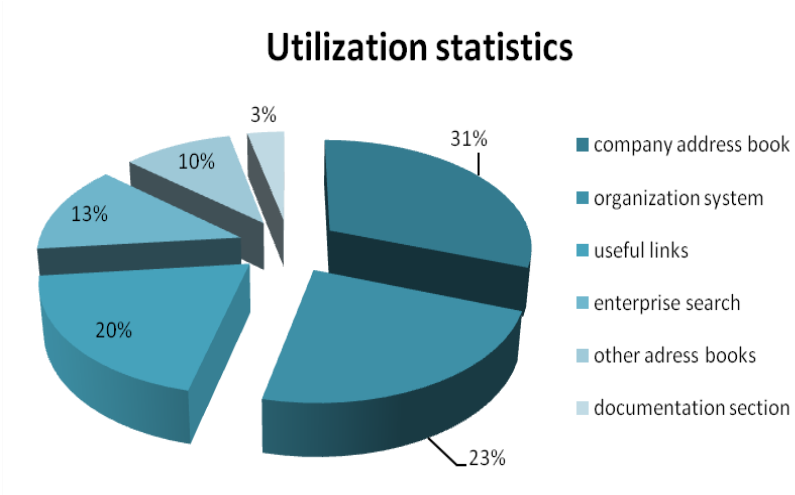

Figure 10: Utilization statistics of a group of application.

The following diagrams highlight the utilization trends after the introduction of an enterprise communication tool for instant messaging, web conferencing and sharing desktop sessions.

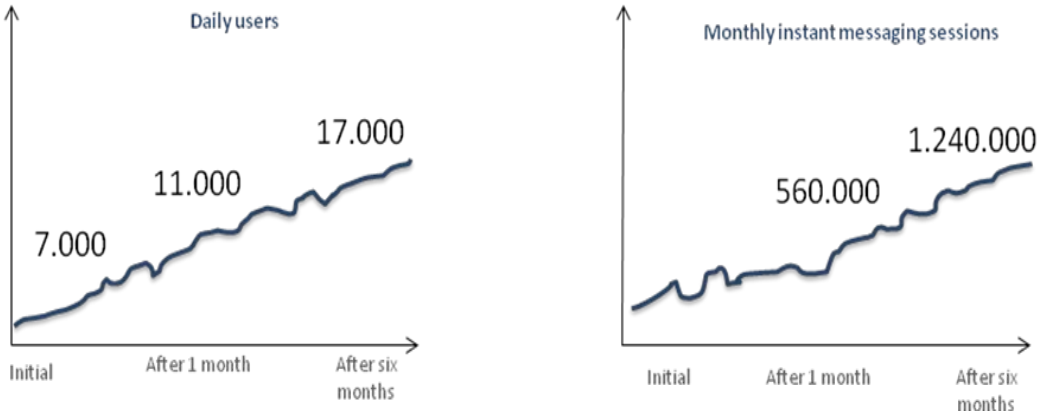

Figure 11: User Trends.

The target of this approach is to support knowledge sharing and transfer by exploiting current technology potentialities. Tools must be useful, easy and well integrated. It is extremely important to monitor utilization dynamics and the user engagement in order to intervene when necessary and to incentivize participation.

User engagement refers to the degree that a viewer or consumer has been positively influenced by a product and it bring participation and involvement. To monitor user engagement, it is necessary to select the right key performance indicators (KPI). In the case of social network KPI are quite different from the classical web sites KPI.
User engagement main objectives are to *enhance the sense of belonging* and to *increase user participation and involvement.* The chosen KPIs are the following ones.

- *Total time spent on site*: shows how thoroughly users are consuming the content.
- *Geographic segmentation*: the audience is divided according to geographic units. It can be useful to tailor programs to fit the needs of individual geographic areas, localizing the effort to geographic differences in needs and wants.
- *Single service utilization statistics*: shows how much users are consuming the single widget/service
- *Inbound and outbound links evolution*: The link analysis display all internal and external links of the website. This metric could be particularly useful for ongoing features helpful to build a regular user base for.
- *Profile completion level*: shows user psychological site loyalty
- *Number of added services*: shows how thoroughly users are interested to the content.

Toolkit selection and customization

Even if "KM activities are all over the map" (Malhotra, 2005), no IT tool can work unless the participants fully understand the benefits and unless employees have incentives to participate (Grant, 2007). Current technologies offer a wide range of products and possibilities. Given the variety of contexts and situations, choosing the right way to apply technology is extremely important, besides the choice of them. For this reason being able to always catch and understand user needs is crucial, especially in a complex environment such as a multinational company.

In this study a social network was selected to better follow employ needs and to facilitate their job. Social networking sites are not only simple tools. They allow users to create their own personal virtual space and a relationship network. This happens through psychological and social dynamics that encourage connections creation and maintenance.

The best way to apply a social network is from learning about the way the web works, through understanding the right innovation metrics and the focus. The new trends of innovation are made by passionate people that move more than in any time in history. Reasons that leaded to a social networks are the given by three social media and web Innovation metrics. The first one is the *return on attention* which is a key metric of attention scarcity and refers to the value we get in return for the time spent looking for what we want and need. Communities demonstrated wide cost reductions and a huge returned value in change of attention. The second one is the *return on information* metric, which is based upon the value of relevant data returned through search. Communities are an ideal pool to find information about people, needs and preferences. The third one is the *return on skills*. Communities are able to attract users with high capabilities and social networks make possible to build a knowledge map. The previous metrics represent the starting strategic objectives of the selected tool, namely generating relationships and engagement and letting the competencies emerge. User participation is favored by the capability of inducing and gratifying the joining pulse, going through the daily user flow. Realization has to be gradual and respect all kinds of needs.

The focus model was the *shelf*. A shelf can be personalized as preferred, can contain own and other objects, can hold working and extra-working contents.

Social networks are not all the same. In this particular case the main purpose was to realize a useful job tool able to create an open and connected place where ideas and discussions could grow in support of innovation and creativity. After the firsts analyses it was decided to make a modular offer to better address the social business needs of diverse users. By delivering a modular software approach, a new working environment, both effective and motivating at the same time, could be introduced. Modules follows users needs detected by the gap analyses and add further advantages. The basic modules allow total collaboration and involvement of the employees. It represents the initial stage to transform conversations into tangible initiatives. The other modules are designed to facilitate interaction, discussion and an exchange of information and to allow the submission of ideas to be commented on, including documents so as to work in a collaborative manner on new content. Additional advantages are given by the reduction of the numerous meetings and of the amount of emails, or simple by retaining a memory of past projects. The main feature is that individuals exchange views between each other in real time and even more accurately *the right information with the right people*.

Action Plan

The collected results give the basis to start to work. The main objective is to improve knowledge sharing and transfer by putting the individual at the center and analyzing social usability and relational motivations. In the current situation systems are very fragmented, but the perception survey shows that people are ready to share knowledge. Quantitative and quality analyses shows people tendencies, which represents the critical factor of the further implementation. First of all people want to find contacts and information about colleagues' position and competences, then they need an integrated system.

According to Malhotra (2005), best practices recommend not to pioneer new technology. For this reason the solution is in exploiting existent social technologies' feature in an integrated way always close to employees needs. The identified solution is a modular social network rich of functionalities. People themselves are ready, but we should move gradually to not counteract the benefit of social technologies. Three phases with different targets have been identified. The first phase's target is to support individual needs, the second phase's target is to improve the collaborative culture, and the third one is to enhance the collective intelligence.

To build a success social network it is necessary to follow a process. The main steps of this action plan are given by the active listening, strategic concept and governance, interface design, implementation, launch and promotion, participation and dynamics monitoring.

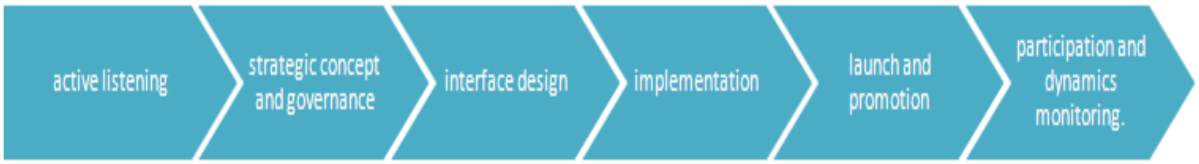

Figure 12: The Process.

Active listening is fundamental to discover people needs. Blowing up the needs permits to choose the right technology to enable. Brainstorming, focus group and AS IS analysis are key aspects of this stage that permit to formalize the contents. The strategic concept is a statement of what is to be done. Focus drivers are given by a shared and informal place, workability, practicalness, community and shared job.
The model is complex and it is necessary to move gradually. First of all it is necessary to work on the needs. Providing a not requested functionality can lead to the *empty room effect*, or rather users don't feel compelled to come back because the conversations doesn't seem active. A problem creates a need, a need asks for a solution. The solution should be delivered on time to not frustrate people, while the interface should be easy, usable and pleasant. Communication is crucial. This new tool aims to be an evolution of communication services and a development of social relationship. In particular the target is to create an informal space where it is possible to share interests, passions, personal skills and achieve actual leadership. It is absolutely important simulate and organize feedbacks to steer the course accurately as in a sailboat.

FINDINGS

The empirical study evaluated the effectiveness of current KM tools in achieving knowledge transfer in an integrated energy company. The paper proposes a tailor made methodology and some best practices to encouraged knowledge sharing in a more structured manner. In particular the paper proposes to use social networks, which are consolidated technologies, by this time.

Social network are strategic tools as they bring a change in organization dynamics. They represent a breaking point such as email introduction was at the beginning. Electronic mail was in fact a crucial tool that allowed multiple users to log from remote places. It started in 1965 and this new ability encouraged users to share information in new ways. In many cases resistance to change was encountered in introducing email inside the companies, as everyone could be able to communicate directly with the CEO, by that time. Now we are facing to another revolution: social networks allow users to create their own personal virtual space in which it is possible to show personal implicit competencies and communicate the own status.

In this study some main aspects are emerged about enterprise 2.0. There are principal reasons why community users decrease in their participation over time. Those are the lack of interest, low quality content, low usability, low trust, merely boring. Every context is different and it is absolutely important take into account people maturity level about new technologies. It is important to carry out every initiative in a gradual way and choose the

strategic objective for each phase basing on people perceptions and needs. Then monitoring is crucial to steer the course on every little change and the emerging of new needs.

To summarize best practices in the application of enterprise 2.0 the golden rule is always analyzing data to be ready to support new requirements and changes. Tools should be usable, easy and well integrated. It is important a continuous and active listening to people and the monitoring of keyword analysis and behavior patterns. To make the transition from individual to enterprise usage, web 2.0 products need to be able to scale to large groups and to operate across the entire enterprise. The enterprise search tool has to be very powerful, as search solutions are blending traditional approaches with web 2.0 functionality.
Effective design is crucial. It presents KM tools in context to enable and encourage usage and contribution. Effective design simplifies functions such as search and browse and also provides efficient contextual access to collaboration tools.

Table 1: what to do and not to do summary.

TO DO	NOT TO DO
Move gradually	Pioneer new technologies
Continuous and active listening	Give soon unrequested functionality risking the empty room effect
Analyze data	Underestimate user feedbacks and perceptions
Provide modular tools	Monitor only the initial KPIs
Monitor keyword analysis	Block people creativity
Be ready to change	
Follow a process	
Design usable and easy interface	
Integrate systems and enhance search tools	

RESEARCH IMPLICATIONS AND LIMITATIONS

These findings revealed the large number of factors impacting on knowledge transfer. It is not so much the knowledge existing in an organization but rather the firm's ability to effectively apply this knowledge that goes a long way to creating new knowledge (Alavi and Leidner, 2003). Social technologies help to leverage knowledge sharing and transfer, but a structured approach should be applied through many steps and different kinds of analysis, ready to always follow user needs.

The paper is based on an application of the described approach to a single, even large, company, which limits the possibility of making general conclusions. The representative nature of the survey group, together with the data collection methods employed, were key strengths of the study approach. However, there is a key limitation of the survey group due to the participation of only a little representative sample of people. Next steps are represented by the analysis of the trends of the utilization of this social network inside this multinational Company.

CONCLUSIONS

In an even more complex world, more openness is required to better understand and integrate expectations of internal stakeholders. Eni demonstrated a great farsightedness

and passion for continuous improvement. Social technologies can help to capture critical information, designing an implicit knowledge real-time map and apply a qualitative and dynamic analysis of people trends. Avoiding their use can be a missed opportunity for the companies, also because people can use external tools like Facebook to state their opinion and show their skills.

KM has evolved to the point where collaboration and contribution is as much a priority as information access. By now the linchpins of KM are not only the ability to lead users to relevant knowledge, but also the capability to promote participation.

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KNOWLEDGE CREATION FOR COMPETITIVE ADVANTAGES USING DIALECTIC MODEL: A STUDY ON ISLAMIC BANK OF THAILAND

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ABSTRACT

Knowledge is a key resource in determining competitive advantage and market place success in the knowledge based society. Knowledge creation is a crucial part that develops the building of the Knowledge Management (KM), since it is concerned with the creation, storage, dissemination, and application of organizational knowledge (Meixell, Shaw and Tuggle, 2002). Since knowledge creation is a mature and established field, a variety of concept and approaches are available to explain them (Nonaka and Nishiguchi, 2001) and were adopted by numerous bodies in nurturing knowledge for their own special purposes. The paper discusses a dialectic movement and its model. The paper suggests a model so called A Dialectic Model in promoting competitive advantage in Islamic banks in order to soften the major challenge of lack in financial engineering and innovation within the framework of Islamic banking. The model applies Thesis-Antithesis-Synthesis Approach, which consists of four main components – thesis, antithesis, analysis, and synthesis. The antithesis component always goes against the thesis. The analysis component is a process in which the thesis and antithesis are taken into consideration in order to enable a Muslim to transact with a bank practicing an interest-free banking system. The analysis part is conducted by reviewing major ideas and precedents or fatwa given by previous scholars seen relevant to the matters without sacrificing the main principle of interest-free transaction as well as the products. A case study on Islamic Bank of Thailand (IBT) in developing a product will be included at the end of the discussion.

Keywords: Dialectic Model, Competitive Advantage, Knowledge Management, Product Development, Islamic Banking

INTRODUCTION

The introduction of Islamic banking system in dominant Muslim countries offers an alternative banking system to conventional one. Muslims perceive that conventional banking system is noncompliant with *Islamic Law (Shariah)* where the current banking practice of offering interest is prohibited by Islam.

The first Islamic financial institution, Saving Bank of Egypt, was established in 1963 by Ahmad El Najjar (Ariff, 1988). It was the first known modern experiment with Islamic banking. This financial institution first operated without projecting an Islamic image due to fear of being seen as a manifestation of Islamic fundamentalism. He pioneered an Islamic banking service in the form of a saving bank based on profit sharing in the town of Mit Ghamr (Siddiqi, 1988).

In 1971, The Nasir Social Bank declared its first interest free commercial bank although its charter made no reference to Islam or Islamic law *(Shariah)* (Ariff, 1988). This is viewed as the second effort to introduce Islamic banking in the world of banking services. The decade of 70's appeared to experience a significant surge of Islamic banking services in the world. Several Islamic banks came into existence in the East, for instance Islamic Bank for Development in Saudi Arabia (1974), Islamic Bank of Dubai (1975), Feissal Islamic bank of Sudan (1977), Bank of Finance in Kuwait (1977) and Feissal Islamic Bank of Egypt (1977) (Ariff, 1988).

Meanwhile, in the Southeast Asia region, the Philippine Amanah Bank (PAB) was established in 1973 by Presidential Decree as a response to the Muslim rebellion in the south. It was designed to serve the banking needs for the Muslim community. However, the primary aim of PAB was to construct Mindanao, Sulu and Palawan in the south (Mastura, 1988). PAB is not a pure Islamic banking based on Shariah since interest based operations continue to coexist with the Islamic mode of finance. PAB operates two 'windows' for conventional and Islamic counters.

Some Islamic financial institutions were also established in countries where Muslim community is minority. There was a proliferation of interest-free saving and loan in India during the seventies (Siddiqi, 1988). The Islamic banking system in Luxembourg was established in 1978, an Islamic Bank International of Denmark, the Islamic Investment Company of Australia (Ariff, 1988) and Islamic Bank of Thailand in 2003.

BACKGROUND TO RESEARCH

The uniqueness of Islamic banking products and services is its interest free banking which is offered to both Muslims and non Muslims customers. However, the study in Malaysia found that non Muslim customers accounted only 2 percent of the total number of its depositors (Man, 1988). This is an indication that Islamic bank's products and services in the early year of its operation in Malaysia failed to attract non Muslim customers. Metawa & Al Mossawi (1998) found that the religious belief and economic became the main factors for Muslims in selecting products and services of Islamic banks. The relationship between Islamic bank and customers cannot depend solely on religious factors. It might not be a problem for a nation where Muslims

are majority, country where Muslims are minority, religious factor is insignificant for competitive leverage.

Numerous studies revealed that religion is no longer the main factor in attracting depositors. Hence, Islamic bank should recognize this by offering products and services compatible to conventional banks (Erol & El-Bdour,1989; Haron & Planisek,1994; Gerrad & Cunniham,1997). A study conducted by Haron and Shanmugam (1995) and Haron and Norafifah (2000) shows that there are negative relationships between interest rate and the total interest free deposits. This clearly displayed that economic factor influences the customers' choice of products and services offered by a bank. This finding is supported by another study done by Radiah (1993). She found that Muslim and non Muslim customers give priority to time value of their saving. This group of customers constitutes sixty percent of Bank Islam Malaysia's depositors.

Thailand is a country where Muslims are a minority. Muslim community constitutes only 10 percent of her population of 63 million. Most of the Muslim community is at the deep south provinces of Thailand of Narathiwat, Pattani, Yala and Satun. Muslim community in these provinces is about 5 million. The rest is staying in other parts of Thailand. Islamic Bank of Thailand was established in 2003, giving an alternative to both Muslims and non Muslims for interest-free products and services. In order to attract non Muslim customers, the Islamic bank must be competitive relative to their conventional counterparts.

However, there are limited researches done on Islamic Bank of Thailand in terms of products and services offered. Therefore, this research aims to study on the competitiveness of Islamic banking products and services in a Non-Muslim nation by using knowledge management model in products and services development. This paper is a conceptual study as a Ph.D. thesis. An empirical investigation is not conducted yet. This paper tries to highlight that the product development process in Islamic banking follows the dialectic model of knowledge creation.

PROBLEM STATEMENT

Knowledge becomes an important asset in creating competitiveness (Fama & Jensen, 1983). If the knowledge of market forces is structured in an appropriate way and by proper utilization of knowledge, the bank can develop more competitive products and services. According to Pitt and MacVaugh (2008), knowledge management (KM) can enhance the effectiveness of new product development but more importantly, it is necessary to manage knowledge in a more structured way. The lack of awareness about knowledge management might lead to the failure of product development (Ferrari & Teledo, 2004). A certain knowledge technique is used in KM and Artificial Intelligence (AI). A study conducted on Taiwanese high companies implementing KM found that there is positive effect on new product development performance and its effective method will lead to the success of new product development (Liu, Chen & Tsai, 2005).

The product and services of Islamic Bank of Thailand are found to be less competitive (IBT annual report, 2010). They are offered to the market without proper understanding and are ill-informed of the market forces and needs. They lack of understanding, awareness and

information that could leverage their offers relative to their conventional banking counterparts This research addresses on the issue by promoting the knowledge creation techniques that should be applied in understanding the whole scenario, creating necessary knowledge within Islamic bank thus addressing the issue of gain competitive leverage. As an attempt to eliminate the constraints faced by Islamic bank, the research proposes the Dialectic Model (Approach) where Thesis, Antithesis and Synthesis techniques are used. However, this model has not been studied yet in the field of banking product development. The model was studied in a manufacturing organization in Japan. The model was successfully formulated a policy effecting both the employers and employees. The outcome is the formulated policy allows a win-win situation for both parties.

RESEARCH OBJECTIVES

1. To study the factors influencing the competitiveness of the Islamic banking products and the services in a nation where non-Muslims are majority.
2. To study dialectic model of knowledge management in developing competitive products in Islamic banking in a country where Muslims are minority.

RESEARCH QUESTIONS

1. What are the factors that will influence the competitiveness of Islamic banking products and services in a country where Muslim are minority?
2. How far can Dialectic Model contribute towards increasing competitive advantages in products and services of Islamic banking?

SIGNIFICANCE OF RESEARCH

1. The model will become a source of reference in developing Islamic banking products and services in Muslim minority countries.
2. The model will become a case study to other parts which are similar in its nature.
3. The outcome of this research will make Islamic banking products and services more competitive in their marketing efforts.

LITERATURE REVIEW

Islamic bank offers unique products and services compared to the conventional one. The uniqueness of Islamic banks is its interest-free banking facility to both Muslim and non-Muslim customers. Depository schemes, similar to conventional banks, are offered by Islamic banks. Islamic banks around the world offer three main types of depository services such as current accounts, saving accounts and investment accounts. Current and saving accounts guarantee depositors the nominal value of the deposit but provide no guarantee on returns. The investment accounts operate fully under the Profit Loss Sharing (PLS) scheme where capital is not guarantee neither any pre-fixed return.

In the case of Bank Islam Malaysia Berhad (BIMB), the products and services failed to attract non Muslim community. Non-Muslim depositors accounted for only two percent of the total number of depositors (Man, 1988). Even though the bank had a network of 533 branches as at the end of September, Islamic banks were used to be unpopular among Malaysian customers.

In Malaysia, there are two main types of depositors among Islamic banking customers. The first group represents those who strictly adhere to the Islamic faith and thus desire to follow strictly the Islamic teaching at any cost. The second group consists of moderate Muslims and non-Muslim customers. Haron and Planisek (1994) found that the former represents only forty percent of the Muslim customers. The later constitutes sixty percent and often consider time value is more important. The authors suggested that the top management of Islamic banks should realize the needs of time value of money and do not solely depend upon Muslims for deposit or as their fund users. Non-Muslims should be included as potential customers. This remark was also supported by Norafifah & Haron (2002).

RESEARCH VARIABLES

Islamic banking system is an alternative banking system to the conventional one. The products offered should be in compliance with *Shariah* law that is interest free. A study conducted by Haron and Wan Azmi (2008) found that religious belief plays an important role for Muslim customers in selecting products and services offered by Islamic banks. Most clients select products and services offered by Islamic bank because they desire to conform to *Shariah* or Islamic principles (Al-Ajmi, Abo Hussain, & Al-Saleh, 2009; Metawa & Almossawi, 1998).

Cooper (2001) stated that one of the common attributes in developing successful products is listening to the customer. Customer inputs can be used to improve and develop product (Plumlee & Little, 2006). According to Goffin and New (2001) customer support is an essential element in successful marketing of products. The prerequisite in ensuring product success in market is the need to understand customer requirement and expectations (Zang, 1998). A product which does not reflect customer needs will lead to the failure (Zirger & Maidique, 1990).

The key changes required of a firm in order to be competitive are its customers and competitors. Firm should determine customer's needs and be informed of the competitors' products. Products should reflect customer's needs and be differentiated from that of competitors (Homburg, Grozdanovic & Klarmann, 2007). By understanding customer's needs and competitors, firms can deliver a product that can give benefits to customers and have advantages over the competitors (Hoonsapon & Ruemroom, 2009). Product Differentiation is a source of competitive advantage. Differentiation means firms offer unique or superior benefits to their customers that competitors do not have (Porter, 1985).

According to Driva, Pawar and Menon (2000), an effectively managing and measuring the product development process is seen as a means of ensuring business survival through reduced time to market, increase quality and reduced costs. This fact is supported by Valle & Avella (2003) in his study on the innovative industries in Spain. They found that an effective product development process is indicated by better development time and cost and superior product. However those indicators can be achieved through an effective leadership.

A competitive product in a market should fulfill demands on quality, performance and cost (Ottoson, 2004). According to Jang, Dickerson and Hawley (2005), the combination of consumer acceptance and financial performance, sale and profitability, served as critical measures for product performance.

The selected variables are as follows:
Independent variables (IV): Shariah, customers' expectation, competitors' products information and product differentiation.
Dependent variables (DV): Customers' acceptance, market shares and profitability
Mediating variable (MV): Leadership

THEORETICAL FRAMEWORK

This section discusses the techniques that could be used, as an attempt to understand the issue and to nurture appropriate knowledge for specific use. It is necessary to be familiar with the techniques regularly used in creating knowledge, so that the strength and weaknesses could be identified.

DIALECTIC MODEL

The research identifies and proposes the Dialectic model (Takeuchi & Nonaka, 2004) for overcoming difficulties, eliminating constraints and solving the problem of creating new product within Islamic Bank. The justifications of the selection is that Dialectic approach takes verbal communication, direct conversation and dialog in its process, where all these have been a normal practice within banking institutions. Dialectic approach is proposed to strengthen and to formalize the current practice.

The Ba and Care, Cooperation, Cross Border and Symbiotic Co-Evolution are focus on learning from other organizations, local and abroad. It could be observation and adaptation from other's experiences and practices, to be implemented locally upon appropriate modification and adjustment to suit organizational needs. While, Induction, Deduction, Abduction and Self Reflection techniques is thought to be logical inference and monologue, without direct responses from personnel of authority. This is inappropriate in order to establish a solution that requires feedback and authorization from others, and thus Dialectic approach seems very promising for this study.

Dialectic Model for Knowledge Creation

This section discusses a dialectic movement and its model. The term "dialectic" originates from Greek *dialektos*, meaning discourse or debate. Plato (428-324 BC) referred dialectic as binary opposites, tensions and contradictions among ideas. The principle developed to include the idea that all levels of knowledge advance through a process of Thesis, Antithesis and Synthesis (Singer, 2003). According to Hegel's dialectic, it comprises three dialectical stages of development: a thesis giving rise to its reaction, an antithesis which contradicts or negates the thesis and the tension between the two being resolved by means of a synthesis.

According to Tekeuchi & Nonaka (2004) dialectics emphasizes two characteristics. The first is its emphasis on change in which it talks about process and movement. Secondly, it emphasizes on opposites. Change takes place through conflict and opposition. It is looking for contradictions within people or situations as the main guide to what is going on and what is likely to happen.

The core in dialectics is the notion of the world as being full of contradictions (Skirbekk & Gilje, 2001). The dialectical movement begins with thesis as the original state. The next stage is for this thesis to show itself to be inadequate or inconsistent. It is the opposite or negation of the first stage and hence is known as antithesis. It is the reaction against the thesis. The second stage also shows to inadequate or inconsistent. So, it results in third stage known as synthesis. It solves the oppositions between the thesis and the antithesis. The previous thesis and antithesis are reconciled and transcended (Takeuchi & Nonaka, 2004; Lind & Melin, 2003). The synthesis is a combination of the best thesis and the best of antithesis. However the synthesis will serve as the thesis for a new dialectic movement. The dialectic movement is illustrated in Figure 1 and Figure 2.

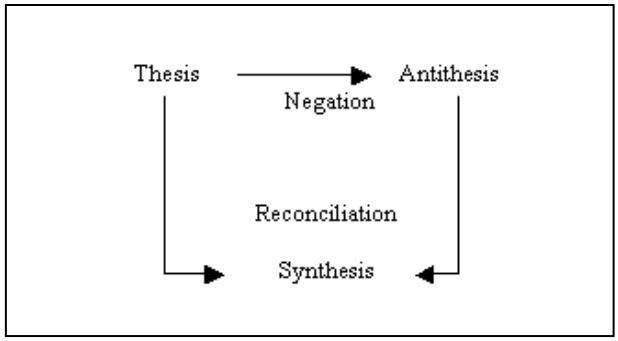


Figure 1: Dialectic Model (Tekeuchi & Nonaka, 2004).

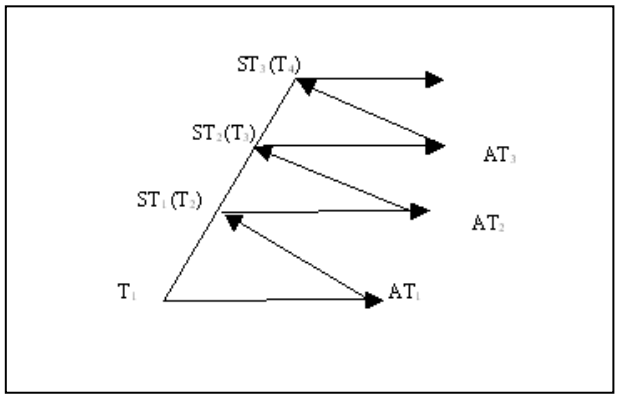


Figure 2: Thesis-Antithesis-Synthesis Movement (Tekeuchi and Nonaka, 2004).

Knowledge creation in dialectic thinking accepts what appear to be opposites and tries to synthesize them by transforming and uniting them. A new reality is created through synthesis. The process involves taking a thesis (T_n) and an antithesis (AT_n) and creating a new reality (ST_n). ST_n is separate and independent of T_n and AT_n. A synthesis (ST_n) is neither something in between nor something in the middle of a thesis (T_n) and an antithesis (AT_n). This relationship is illustrated in figure 2 above. A thesis (T_n) may represent interest or culture or practice of an individual or an organization meanwhile an antithesis (AT_n) may represent the interest or culture or practice of a community or a customer in which both are contradict to each other. In order to solve the problem or the conflict between a thesis and antithesis, the organization has to come up with a solution (ST_n). It is not a compromise, but has a higher or broader view of reality. It is a "super-proposal" that encompasses the conflicting thesis and antithesis in it. The process involves dynamic interaction for self-realization (Buss, 1979). Discovering a new knowledge it needs critical thinking by considering all possible internal and external variables of an organization that lead to "super-proposal".

Critical thinking or critical reasoning is a major topic on enhancing the effectiveness of human judgment and decision making (Ennis, 1992). Critical thinking is a skill for many complex problems in which normal procedures cannot be successfully used to solve a decision problem. Critical thinking is used to search for alternative solution, procedures or beliefs to arrive at innovative solution. Halpern (1984) defines critical thinking as thinking with a purpose and a goal. Critical thinking involves reflective and healthy skepticism requires deepening the background knowledge about the decision problem, and calls for a greater cognitive effort in selecting facts and assumptions to use (McPeck, 1992).

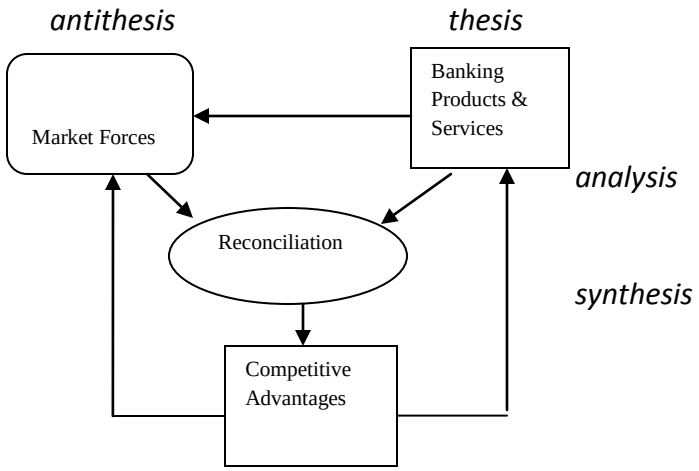


Figure 3: Conceptual Framework of the Study based on Dialectic Model.

The above figure represents a dialectic model which consists of several components of thesis, antithesis, analysis and synthesis. Thesis represents the products and services of Islamic bank which are interest free and have an equitable distribution of income and wealth and to increase equity participation in the economy (Chapra, 1982). Second component is antithesis, which represents the market forces. In this case thesis and antithesis always negate each other and there is a contradiction between those interests. The bank's interest is always driven by high profitability with low cost meanwhile the customers are driven by a high return from their savings and investments. They will deposit their money to banks that offer a high return (Erol & El-Bdour, 1989; Haron & Planisek, 1994 and Gerrad & Cunningham, 1997).

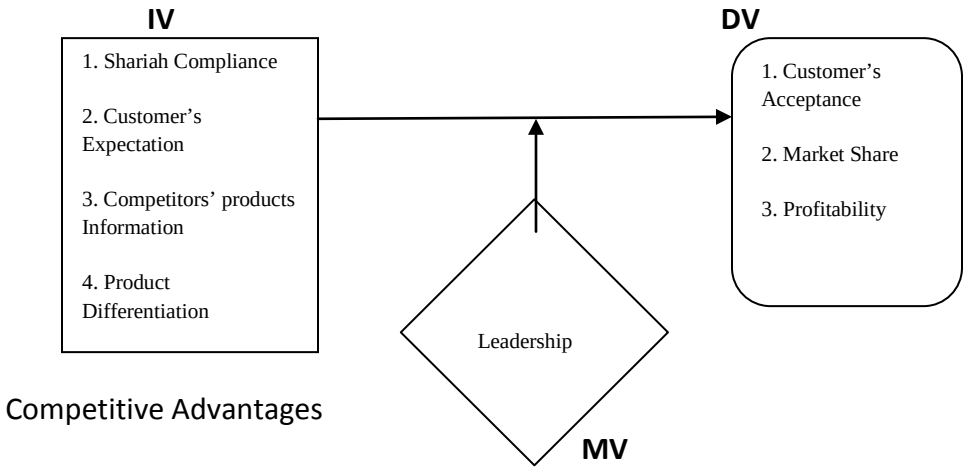


Figure 4: Research Variables.

The analysis is a process of reconciliation between those thesis and antithesis components. The process of analysis will consider several factors that can offer the best products and services without sacrificing the organization's interests and goals as well as customers' expectation. In order to formulate a new product, several variables are taken into consideration including

internal and external factors. The external factors represent the market force that can influence a product development. Those internal variables represent products and services offered by the bank.

DATA COLLECTION METHOD

The research will use qualitative in collecting data due to time constraint and some financial data are confidential. The qualitative method will study the effectiveness of the model in product development. Secondary data will be analyzed and interview will be used to identify its competitiveness.

A STUDY ON ISLAMIC BANK OF THAILAND (IBank)

The establishment of the Islamic Bank in Thailand was initiated by the Muslim entrepreneur living in the three southern provinces. They are formed to adhere to the Islamic way of life, following the principles of Islamic teachings. In 1998 the government propelled the development of Islamic banking system in many forms, especially to serve the Muslims' banking activities in conformity with the Shariah principle. The government's intention was to set up an Islamic Bank under her jurisdiction and managed under its own sets of law. The Ministry of Finance was then assigned to draft 'The Islamic Bank of Thailand Act' which was later approved by the parliament in October 2002.

During the initial stage of incorporation Islamic Bank focused solely on Muslim market segmentation. However IBank believes that Shariah banking system can serve anyone and thus creates and develops more innovative and competitive products. IBank then embarks on the rebranding exercise by offering the best services to customers. The Bank promotes ethical culture, social responsibility, Islamic principle and good governance through its operational framework. IBank is able to differentiate from the other conventional banks while offering new alternative banking for everyone regardless of religion. Currently IBank is a state owned enterprise and has 29 branches throughout the country (IBank, 2009).

Islamic Bank of Thailand is set up under the Islamic Bank of Thailand Act 2002 and regulated by the Ministry of Finance. The Bank commenced operations in June 2003 with paid-up capital of 1 billion baht and had its head quarter and the first branch in Klongton. The Bank continued to open more branches, especially in Bangkok and Southern provinces and by the end of 2005 the Bank had total of 9 branches. The expansion of the Bank's business continued through the acquisition of Shariah Banking Services of Krung Thai Bank Pcl. in November 2005. It was conducted under the government's policy and led to the increase of the number of branches increased from 18 to 27. In order to facilitate the growing business and increase competitive effectiveness the bank relocated the head quarter from Klongton to Asoke, a prime business area, in August 2005 (Islamic Bank of Thailand, 2011).

According to the market share report of IBank as on March 2011, The bank has 1.25% market share in financing (85.4 billion baht) and 1.32% (94.3 billion baht) of market share in deposit

(Market Share of Bank in Thailand, 2011). Table 4 shows the IBank profit. The profit rose up to 355.2 million baht in 2009 from 2.08 million baht in 2008. This represents an extreme 16,905 % increase in profit. The IBank deposit significantly went up to 40.8 billion baht in 2009 compared to 19.9 billion baht in 2008, which was 100 % increased in proportion (Islamic Bank of Thailand, 2009).

Table 1: Market Share of Bank in Thailand on March 2011.

BANK	Financing		Deposit	
	Amount (Million Baht)	Market Share (%)	Amount (Million Baht)	Market Share (%)
KTB	1,227,271.57	17.96	1290550.44	18.05
BBL	1,182,437.48	17.30	1,441,903.84	20.17
SCB	1,051,632.91	15.39	1,112,097.39	15.55
KBANK	1,040,742.51	15.23	1,156,075.10	16.17
BAY	570,874.40	8.35	579,257.14	8.10
TMB	366,543.11	5.36	420,798.66	5.89
TBANK	329,370.78	4.82	234,418.48	3.28
SCIB	258,174.52	3.78	285,402.21	3.99
UOB	157,800.39	2.31	143,331.30	2.00
STANDARD CHATTERED	98,975.58	1.45	105,080.70	1.47
CIMB	91,163.65	1.33	94,767.43	1.33
IBANK	**85,388.02**	**1.25**	**94,290.56**	**1.32**

Source: Islamic Bank of Thailand (2011)

Table 2: IBank Financial Status.

Financial Status	Million Baht		% of change
	2009	2008	(2009/2008)
Assets	45,343	23,835	90.24
Loan	37,958	16,687	127.47
Loan accrued income-Net	37,626	16,421	129.13
Deposits	40,759	19,989	104.84
Total Liabilities	41,848	20,754	101.64
Shareholder's Equity	3,495	3,081	13.43
Income from loan issuance	1,485	821	80.90
Total Income	1,752	925	89.27
Profit net	355	2	16,205.28

Source: IBank Annual Report 2009 (2010), p. 2.

IBANK'S CORE PRODUCTS

The products, which are offered by The Islamic Bank of Thailand, are similar to the products offered by other conventional banks. However, the main different principle is all IBank's products are interest-free. Due to the global economic downturn, economic growth in Thailand drastically slowed down. There were unfavourable signs of the economic situation of the Thai people. The Islamic Bank of Thailand realized the difficulties and needs of customers, so the bank adjusted the features of two credit products namely, home financing, home refinancing, and created additional refinancing on credit card debt and personal financings. These three

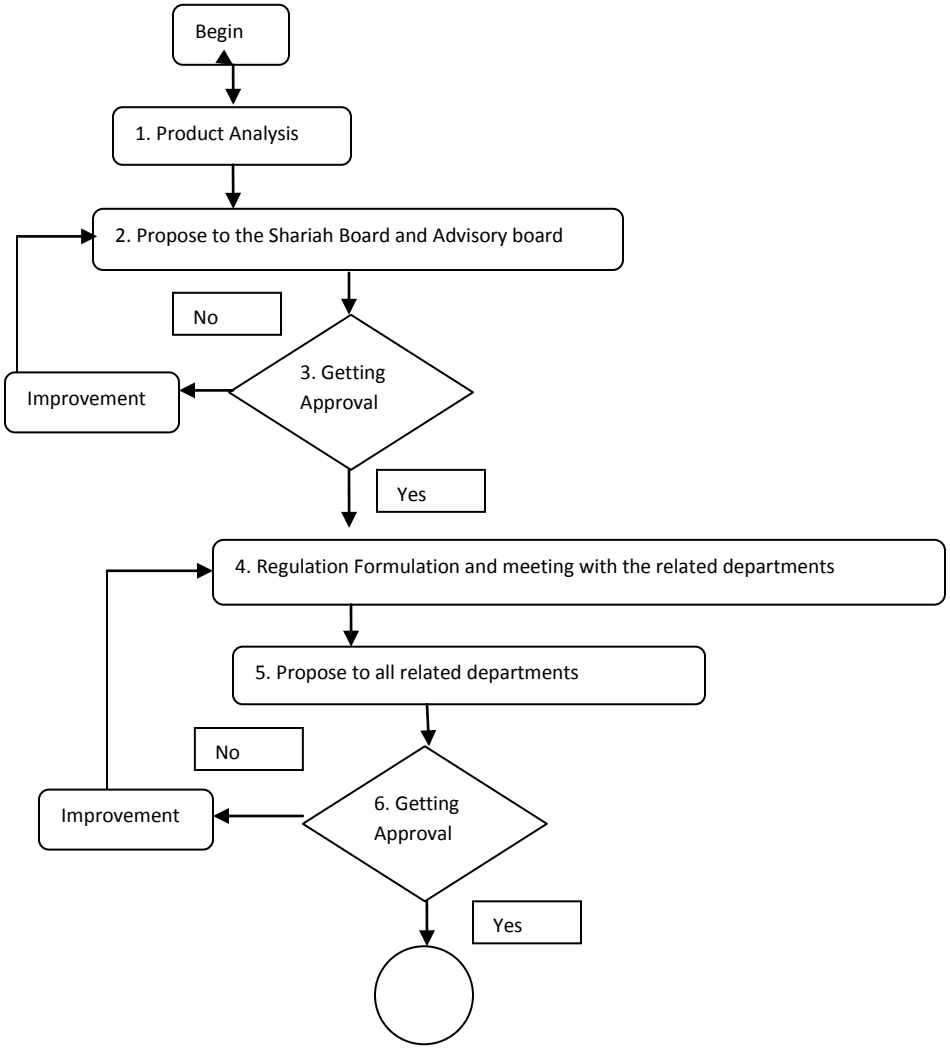
products are on packaged under the relief credit project, with the distinguishing characteristic of grace periods of principal repayment as long as three years for home financing and six months for the refinancing of credit card debt and personal financing. The rate of profit was less than half when compared to the burden of instalment payments to the original institutions of customers. These three products turned out to be well-received by the Bank's customers, making the total sales volume of these three products exceed 50% of the total amount of personal financing, and making this project well-known as a product champion of the year for the Bank.According to an interview with Mr. Shah Fahad Yousufzai, the vice president of product development department on 24th March 2011, these products are considered the most competitive products due to the amount approved and the number of customers.

PRODUCT DEVELOPMENT PROCESS

Figure 5 shows the flow of a product development process. All products offered by IBank must go through the above flow. The most important variable in IBank's product's offering in the market is compliance with Shariah law. The process of designing a new product begins with product development analysis. There are several factors taken into consideration in designing a new product. The process requires gathering several information such as the information from sale department, competitors products, rules and regulation of Bank of Thailand, information from every business sector, market needs, customers' behaviors, domestic and international market and economic tendency and the interest rate tendency both for deposit and loan. Although a new product has fulfilled the required analysis but does not meet the Shariah compliance, the products are not allowed to enter the market. New product must be pre-approved by the Shariah board before getting the approval from the executive committee and the board of directors. When a new product does not get the approval from the Shariah board, it should be revised and to realign with Shariah as recommended by the Board of Shariah.

The Board of Shariah will look at the Shariah law according to the verdicts revealed by the Muslim scholars of Sunni sect from the four main schools. They are Maliki, Hambali, Hanafi and Syafie schools of thought because these opinions are considered the most influential verdicts in Sunni sect. The Shariah board will choose the most flexible verdict from the opinions in order to make sure that the business can run smoothly and accordance with Shariah. However, the products and opinions might be different from one Islamic bank to the other in different countries. It is based on which opinions are chosen by the board of Shariah. For example, Bai Inah (sale of cash) personal refinancing is offered only by Islamic Bank of Thailand based on Bai Inah principle. In the Middle East countries, the product is considered doubtful to Shariah compliance. According to Maliki, Hanafi dan Hambali schools, Bai Inah is a void contract but it is acceptable with discourage in Shafie and Zahiri schools (Saiful Azhar Rosley, 2005).

Figure 5: The flow of product development process (Islamic Bank of Thailand, 2011).



CONCLUSION

Gaining competitive advantage should be following some schema of knowledge creation. Having sufficient and appropriate knowledge that are created and tailored to specific needs of a banking institution would be very useful so that it could create, refine, improve and eventually offer product and services at customers' preferences. The research shows that the most influential factor in Islamic banking is Shariah. The product must meet the requirement of Shariah first before offering to a market. Secondly, the Islamic Bank of Thailand is following the model in developing a competitive product in order to fulfill market's needs. Even though Islamic products have to be compliant to Shariah but the law is flexible and can create competitiveness by looking at different schools of thought. The research proves that the Dialectic Model is an appropriate approach for creating new knowledge and the necessity of that knowledge in assisting Islamic banking institutions gaining competitive advantage. However, the main obstacle for Islamic Bank of Thailand is a regulation regarding taxation. We recommend for a further research to conduct a research in finding a solution to wave tax for the Islamic banking system because the bank has to pay double taxes, which are social obligation (zakat) and company income tax. The current Banking Act in Thailand makes the bank becoming less profitable.

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KNOWLEDGE MANAGEMENT AND PROJECT MANAGEMENT

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ABSTRACT

On a global basis, organizations are recognizing the importance of knowledge as a means of gaining or sustaining competitive advantage. Researchers have concluded that the only thing that is sustainable for successful businesses in the New Millennium – is what it knows, how it uses what it knows, and how fast it can know something new. Many organizations are primarily knowledge-focused and project oriented. They obtain data and information and produce either a product or service. In the project management process they use their own, and other's, knowledge and information. Much of the knowledge in an enterprise is grounded in the minds of employees. Past experience and internal learning create processes, insights, methodologies, know-how and understanding that represent what the business is and how it adds value. Since knowledge is the most basic of all competencies, its localization, acquisition and development, transfer, codification and application should be a critical success factor for attainment of a competitive advantage. In the article the knowledge management and project management concepts are described.

Keywords: knowledge management, project management, knowledge, information

INTRODUCTION

The role of knowledge as the key source for competitive advantage in enterprises has become very important. The idea that knowledge can be managed is fundamental to the related notions of the knowledge-based business, the learning enterprise and the management of intellectual capital. The recent interest in these overlapping concepts reflects important phenomena, which enterprises have to deal with, such as perceptions of increased competition, rates of change and market turbulence. Enterprises are hence looking for new ways to remain in business or compete effectively. One crucial way to achieve effectiveness is to recognize or rediscover assets the enterprise already has but is not utilizing to their full potential. Knowledge is a vital resource in project-based industries such as aerospace, construction, shipbuilding and software. If managed effectively, knowledge can be used to reduce project time, improve quality and increase customer satisfaction. However, the management of intellectual assets is a new and challenging process for project-based industries.

Identification of critical knowledge and the ability to utilize it is a challenge for any project organization. Successful project management is based on accumulated knowledge, and, on the other hand, on individual and collective competences.

In this paper knowledge management and project management concepts were described. The differences and possible synergies between these two conceptions were presented.

THE CONCEPT OF KNOWLEDGE MANAGEMENT

A useful way of arriving at a definition of what knowledge is can be achieved by differentiating it from what it is not. One of the most common distinctions in the contemporary knowledge literature is between knowledge, information, and data. Data is a set of discrete, objective facts about events. Information is a message, usually in the form of a document or an audible or visible communication. As with any message, it has a sender and a receiver. Information is meant to change the way the receiver perceives something, to have impact on his judgment and behavior. Knowledge is broader, deeper, and richer than data or information. Knowledge can be understood to emerge from the application, analysis, and productive use of data and/or information. In other words, "knowledge can be seen as data or information with further layer of intellectual analysis added, where it is interpreted, meaning is attached, and is structured and linked with existing systems of beliefs and bodies of knowledge" (Hislop, 2005).

In organizations, knowledge often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms. Knowledge is a mixture of various elements; is fluid as well as formally structured; is intuitive and therefore hard to capture in words or understand completely in logical terms. Knowledge exists within people, part and parcel of human complexity and unpredictability.

There are many definitions of knowledge management, for example Gupta et al. (2000) defined it as "a process that helps organizations find, select, organize, disseminate and transfer important information and expertise necessary for activities such as problem solving, dynamic learning, strategic planning and decision making". According to Awad and Ghaziri (2004) knowledge management is a newly emerging, interdisciplinary business model that has knowledge within the framework of an organization as its focus. It is rooted in many disciplines, including business, economics, psychology, and information management. It is ultimate competitive advantage for today's firm. Knowledge management involves people, technology, and processes in overlapping parts. Liebovitz (2003) considered it as dealing with capturing, sharing, applying and creating knowledge in an organization to best leverage this resource internally and externally. Dunn and Neumunster (2002) define knowledge management as a systematic approach to managing and leveraging an organization's knowledge assets, which may include knowledge of the organization's customers, products, markets, processes, finances and personal services. Novins (2002) shortens the definition to simply say knowledge management can be thought of as packaging the right content and delivering it to the right people who can make use of it at the right time.

Organizations possess two kinds of knowledge: external and internal. External knowledge reflects awareness of regulations, competition and market trends, as well as the ability to anticipate a market. Internal knowledge includes an understanding of core competencies, know-how, strengths, weaknesses and lessons learned from past experiences (Frappaolo 2000).

All organizations generate and use knowledge. As organizations interact with their environments, they absorb information, turn it into knowledge, and take action based on it in combination with their experiences, values, and internal rules. Without knowledge, an organization could not systematize itself; it would be unable to maintain itself as a functioning enterprise. Knowledge generation means the knowledge acquired by an organization as well as that internally generated and developed within it. Acquired knowledge does not have to be newly created, only new to the organization. There are five modes of knowledge generation in organization (Davenport, Prusak, 1998):

1. Acquisition. The most direct and often most effective way to acquire knowledge is to buy it – that is, to buy an organization or hire individuals that have it. Outside knowledge can be leased or rented. A common type of acquisition is a firm's financial support of university or institutional research in exchange for exclusive rights to commercial use of promising results. Renting knowledge really means contracting a knowledge source. Hiring a consultant for a project is an obvious example. Using reputation as a key measure of value, a company will pay a consultant fee to share in that consultant's knowledge or apply it to a particular project.
2. Dedicated resources. A customary way to generate knowledge in an organization is to establish units or groups specifically for that purpose. 'Research and development' departments are the standard example. Their whole aim is to gather and come up with new knowledge – new ways of doing things.
3. Internal fusion. Knowledge generation through internal fusion purposely introduces complexity and even conflict to create new synergy. It brings together people with different perspectives to work on a problem or project, forcing them to come up with a joint answer.

   Here are five knowledge management principles that can help make fusion work effectively:
   - Foster awareness of the value of the knowledge sought and a willingness to invest in the process of generating it.
   - Identify key knowledge workers who can be effectively brought together in a fusion effort.
   - Emphasize the creative potential inherent in the complexity and diversity of ideas, seeing differences as positive, rather than sources of conflict, and avoiding simple answer to complex questions.
   - Make the need for knowledge generation clear so as to encourage reward, and direct it toward a common goal.
   - Introduce measure and milestones of success that reflect the true value of knowledge more completely that simple balance – sheet accounting.
4. Adaptation. A company can adapt new products from competitors or new technologies. A firm's ability to adapt is based on two principal factors: first, existing internal resources and capabilities that can be utilized in new ways, and second, being open to change or having a high "absorptive capacity." The most important adaptive resources are employees who can acquire new knowledge and skills easily.
5. Networks. Knowledge is also generated by informal, self-organizing networks within organization that may over time become more formalized. Communities of knowers, brought together by common interests, usually talk together in person on the

telephone, via e-mail and groupware to share expertise and solve problems together.

Alavi and Leidner (2001) note that knowledge may be viewed from five different perspectives:

- state of mind perspective, emphasizing knowing and understanding through experience and study;
- object perspective, defining knowledge as a thing to be stored and manipulated;
- process perspective, focusing on knowing and acting;
- condition perspective, emphasizing access to knowledge;
- capability perspective, viewing knowledge as a capability with the potential for influencing future action.

These different views of knowledge lead to different perspective of knowledge management:

- IT perspective, focusing on the use of various technologies to acquire or store knowledge resources (Borghoff, Pareschi, 1998). As knowledge is viewed as an object, knowledge management should focus on ensuring that explicit knowledge, available in the form of knowledge items, is widely accessible across an organization;
- Socialization perspective, focusing on understanding the organizational nature of knowledge management (Gold, Malhotra, 2001; Becerra-Fernandez, Sabherwal, 2001). Knowledge management should focus on supporting the processes of sharing, creating, and disseminating knowledge;
- Information system perspective, focusing on both IT and organizational capability and emphasizing the use of knowledge management systems (Schultze, Leidner, 2002; Tiwana, 2001). The right knowledge management strategy should be put in place to develop and nurture core organizational competencies, and create intellectual capital.

Thus far, a number of researchers have attempted to classify the major activities of knowledge management. For example Nonaka and Takeuchi (1995) focused on the dynamics of knowledge activities and suggested that the four major activities of knowledge management are socialization, externalization, combination and internalization. Despite its seminal contribution, this list of activities is too conceptual and even philosophical to be used in actual practice. Other versions are abundant. For instance, Tiwana (2000) suggested three fundamental activities, acquisition, sharing and utilization. Ruggles (1997) proposed such activities as generation, codification and transfer. Marquardt (1996) suggested four activities, acquisition, creation, utilization and storage. Wigg's (1993) version consists of four activities: creation and sourcing, compilation and transformation, dissemination, and application and value realization. Van der Pek and Spikervet (1996) proposed four activities: developing, securing, distributing and combining. Some other researchers presented more extensive frameworks consisting of six activities, namely acquire, select, internalize, use, generate and externalize (Holsapple, Joshi, 2002), or eight activities: identify, capture, select, store, share, apply, create and sell (Liebowitz, Beckman, 1998).

According to Paliszkiewicz (2007) knowledge management consists of five processes: localization, acquisition and development, transfer, codification, and usage. Knowledge

localization includes all activities, which indicate, where knowledge exist. Knowledge acquisition and development includes the knowledge acquired by an organization as well as that developed within it. Acquired knowledge does not have to be newly created, only new to the organization. Knowledge transfer is transmission of knowledge (experience, lessons learned, know-how) and use of transmitted knowledge. It is conveying the knowledge of one source to another source. Knowledge codification is the capture of knowledge so that it can be re-used either by an individual or by an organization. The aim of codification is to put organizational knowledge into a form that makes it accessible to those who need it. If knowledge management is to thrive, organizations must create a set of roles and skills to do the work of using knowledge.

Lin and Kim (2001) propose that organizational capability of knowledge management grows through the following four stages: initiation, propagation, integration, and networking. The stages in life cycle theory are sequential in nature and hierarchical in progression (Quinn, Cameron, 1983; Van de Ven, Poole, 1995). Therefore, each stage of the suggested model can be seen as a necessary precursor of the succeeding stages.

The first stage is an initiation stage in which organizations start to recognize the importance of organizational knowledge management and prepare for enterprise-wide knowledge management efforts. Environmental pressures such as rapidly changing socioeconomic and technical factors, globally increasing competition, and changing customer demands for knowledge-intensive products or services enforce the implementation of knowledge management (Demarest, 1997; Myers, 1996; Prusak, 1996). Consequently, organizations should clearly specify shared visions and goals of knowledge management and disseminate them over the whole organization through diverse communication channels.

The propagation stage is a stage where organizations start to invest in building their knowledge infrastructure to facilitate and motivate knowledge activities such as creating or acquiring, sharing, storing, and utilizing. Since organizations have already prepared for their knowledge management initiatives in the previous stage, the real enterprise- level efforts for knowledge management can start from here.

The integration stage is where organizational knowledge activities are institutionalized as daily activities over the whole organization. Management focus is placed on the integration of organizational knowledge and knowledge activities. As all organizational members become familiar with knowledge activities, the level of knowledge activities and knowledge accumulation reaches its highest levels.

The final networking stage is an external integration stage where organizational knowledge is networked not only within an organization but also with external entities such as suppliers, customers, research firms, and universities. As more and more organizations initiate knowledge management efforts, sustainability of competitive advantage from knowledge management becomes harder to come by. Generally, under the more severe competition, organizations usually concentrate its resources and executive time on core activities where it can perform at the best-in-the-world levels (Quinn et al., 1996). Organizations at this stage will also start to focus their organizational efforts on specialized core knowledge and outsource other needed knowledge from outside.

Organizations need to establish teaching and dissemination standards for their business to enable them to manage their knowledge assets better.

They are required to meet the following conditions (Macintosh, Filby, Kingston, 1999).

1. Promote the importance of knowledge management and the awareness of how knowledge management is to be achieved within, and across, operational divisions.
2. Create an awareness of a framework to achieve knowledge management.
3. Develop a skill base of personnel who have knowledge management skills to enable them to facilitate the development, use and sharing of the organization's knowledge assets.

Management of knowledge assets is difficult for reasons such as the following (Macintosh, Filby, Kingston, 1999).

- Knowledge exists at different levels of abstraction whose relevance depends on the user;
- The value and acceptability of knowledge varies greatly depending on the user;
- Knowledge does not have a fixed quality, it becomes out of data as time elapses;
- Knowledge is intangible and often incomplete, and is therefore very difficult to describe.

THE CONCEPT OF PROJECT MANAGEMENT

According to definition, a project is a complex, non-routine, one-time effort limited by time, budget, resources, and performance specifications designed to meet customer needs (Gray, Larson, 2006). It can also be viewed as a set of temporary activities conducted by an ad hoc organization (Olson, 2004). A project has a definite beginning, definite ending, and has several interdependent tasks. Unfamiliarity and uniqueness are also often described as characteristics of a project. As a discipline, project management is assuming importance similar to other disciplines in an organization such as engineering (Rad, Levin, 2002).

Organizations that support such non-routine, one-time efforts are known as project organizations, where functional lines of authority are not key to organizational success. The project organization is highly conducive to innovation, since new products and processes evolve from new ideas discovered during cross-functional, team-working interaction. This type of environment is often viewed as a vehicle for change and improvement, generally resulting in significant benefits for the company.
Project organizations are generally composed of many project teams carrying out several projects for an organization at once. Project teams are groups of people with the unique, specialized skills that come together to accomplish a particular assignment. The core of a project team includes the roles of project manager, task leaders and project expediters (or coordinators).

According to Microsoft's Sure Step Methodology, there are six phases in IT projects: diagnostic, analysis, design, development, deployment and operations. Every phase is defined by activities and products delivered by involved parties.

1. Diagnostic phase – starts simultaneously with the sales and quoting process, while basic requirements for customer's project are being gathered. The main target of

this phase is definition of key requirements, project goals, pointing of key business processes included in the project and presentation of rough project plan and scope. As the result of the phase is signed contract between parties and formal decision of project startup.

2. Analysis phase – is official start of the project. Detailed business analysis is being conducted to gather definition of customer's requirements in context of new project. The main target of this phase is creating and approval of Functional Requirements Document, which is the basis of design and development work. Also formal documents are created, such as Project Charter and Project Schedule.
3. Design phase – starts after the functional requirements (business analysis) are approved and signed. The phase covers design of specific system solutions for every identified process and procedure. The key products of the phase are Functional Design Document describing mappings of recognized procedures to standard system features and Technical Design Documentation describing adjustments of standard system for every identified functional gap.
4. Development phase – covers configuration and programming for every identified and planned business processes. The products of this phase are: prepared technical infrastructure and finalized solution, including programming of extensions, integrations and required data migration modules.
5. Deployment phase – is preparation of the company for startup of new system, what includes final set up of environments, users training and data migration. Main products of the phase is go-live-plan, results of acceptance and performance tests. The final step of the phase system Go Live.
6. Operations phase – focuses on support for the customer in the first period of system usage. The project is being closed and transited to service and maintenance. Main products of the phase are Project Closing Document, Lessons Learned and Service Level contract for support services.

KNOWLEDGE MANAGEMENT AND PROJECT MANAGEMENT

Project management and knowledge management disciplines are related. Both the disciplines have some common aspects and differences. Some of these aspects (*purpose, focus area, time, functions, communication, organizational structure, technology, organizational knowledge, investment*) are discussed below to develop a better understanding of both the disciplines and their relationship.

Purpose

The purpose of project management and knowledge management differ as their goals differ. From its definition, it is clear that project management is concerned with completing a project on time, within budget, and according to the project specifications while satisfying both the customer and project team expectations. A knowledge-based organization attends to two related processes that underline these direct processes: the effective application of existing knowledge and the creation of new knowledge. The goal is fourfold: to ensure that knowledge from one part of a company is applied to activities in other parts; to ensure that knowledge is shared over time so that the company benefits from past experience; to make it possible for people from various parts of the organization to find one another and collaborate to create new knowledge; and to provide opportunities and incentives for

experimentation and learning. Knowledge management is a deliberate effort to develop knowledge and apply it to improve performance throughout the enterprise.

Focus area

The focus areas of project management are: schedule, cost, scope, performance, and customer satisfaction. Knowledge management focus areas are: delivering innovating products and making process more innovating, faster work, cheaper work, better quality, and respecting customer needs. Both project management and knowledge management are practical and action-oriented disciplines. Though projects aim is to meet organization goals, the focus level of project management is confined to projects whereas knowledge management focuses on enterprise level and improvements in performance.

Time oriented perspective

The project aim is to realize the goal in the given time by the project team. Knowledge management is requiring a long-term time period and significant organizational resources such as human power, capital and managerial efforts (Davenport, Prusak, 1998; Prusak, 1996). Therefore, organizations need to make a long-term plan for organizational change into a knowledge management paradigm strategically and systematically. Building a special team for initiating knowledge management and the acquisition of the needed human resources and budget are prerequisite activities.

Functions

Project management is a discipline that involves planning and controlling functions in the process. Project management is very much concerned with working together in teams, learning from each other, sharing knowledge, and collaborating on efforts to improve efficiency and effectiveness of projects. The activities - working in teams, learning from each other, and collaborating to improve efficiency and effectiveness - are also an integral part of knowledge management. Mentoring and shadowing are examples of knowledge sharing techniques that project managers can use in order to transfer tacit knowledge for improved succession planning, leadership, and teamwork. Equally important are the issues of the role of the project manager in selection and recruitment, performance management, contract administration, and the importance attached to individuals and subcontractors with requisite knowledge, competencies, and wisdom as part of the wider intangible assets. Knowledge management should play an integral part of an organization's human capital strategy to encompass the various types of knowledge from these individuals and organizations (Liebowitz, Megbolugbe, 2003). Knowledge management uses activities connected with knowledge sharing to accomplish its objectives of improving efficiency and effectiveness.

Communication

Effective communication is a critical success factor for both project management and knowledge management disciplines. The larger and more complex the project is, the greater importance assumes the communication, as the number of communication channels is associated with the number of people and disciplines involved in a project. The main functions of knowledge management – localization, acquiring and developing knowledge, transfer, storing the knowledge efficiently, and utilizing knowledge – rely on communicating effectively and efficiently. While project communications are generally real-time, knowledge

management communications can be real-time and can happen after the knowledge has been discovered originally. Knowledge management may help improve communications and provide more informed knowledge to the project manager and project team. In this manner, project goals and objectives could be better articulated and shared among the team members. Additionally, knowledge management systems could be created to ensure a better sharing of best practice documents, lessons learned, project management and systems engineering methodologies.. For example, it can be done by building a Project Management Web Site to have a repository of documents to help the various flight programs and projects in seeing what others have done. These documents are being linked to each stage of project development.

*Organizational Stru*cture

Both of the disciplines influence the structure of an organization. However, project management's influence in changing organization structure is more obvious. Many organizations, which are routinely involved in multiple projects, changed their organizational structures from functional organizations to pure project or matrix organizations.

In knowledge management the main concerns of organizational managers at this point are how to build knowledge structure efficiently and how to expand knowledge activities. The organizational structure includes a measurement and reward system (Tampoe, 1996), human resource management such as training and education, promotion, recruiting policies (Quinn et al., 1996), flexible organizational structure (Nonaka, 1994), and guidance oriented leadership (Von Krogh, 1998; Senge, 1990). Additionally a complete knowledge management process is defined and applied enterprise-wide, including the related rules and policies as well as a permanent team for enterprise knowledge management. In creating appropriate knowledge structure also important are informal networks such as communities of practices.

Technology

Contrary to common beliefs, both are not dependent on technology as it has only a supportive role for these disciplines. Project management uses technology tools such as project management application software and risk analysis software to plan, monitor, analyze, and control project performance. Knowledge management uses information technologies, especially communication and database technologies, to facilitate and support the knowledge management activities (Earl, 1996). The most popular and common approach is implementing a knowledge management system or knowledge repository system to help organize the enterprise-wide knowledge resources (O'Leary, 1998; Liebowitz, Wilcox, 1997; Ruggles, 1998). The computational power of computers has little relevance to knowledge work, but the communication and storage capabilities of networked computers have made them 'knowledge enablers.'. Through e-mail, groupware, Internet, and Intranets, computers and networks can indicate people with specific or required knowledge and connect those people who need to share given knowledge over a distance. Desktop videoconferencing and multimedia computing that transmit voice and video, as well as text, make possible to interface the richness and subtlety of one person's knowledge with others. What we must remember is that this new information technology is only a pipeline and storage system for knowledge exchange. However, these technology tools in both the cases (project management and knowledge management) do not create knowledge and cannot

guarantee or even promote knowledge generation or knowledge sharing in an organizational culture that doesn't endorse such interfacing activities.

Organizational knowledge

People involved in projects are not only organizationally but also geographically dispersed. They have diverse backgrounds and may speak several languages. For example, in order to develop a new product, a company may bring in people from suppliers, clients and universities. But projects are temporally limited, and the people involved, and the lessons learned are dispersed when the project ends. The people often join or leave project during its time being. Sometimes it is difficult to find people who have been involved in a project from its beginning. Combined with employee empowerment and information decentralization typical to project organizations, this results in organizational knowledge fragmentation and loss of organizational learning (Jarvenpaa, Ives, 1994). Knowing about sources and types of knowledge and people who create it in each phase of project can guide for better feedback system. One of the main challenges of project management should be recording knowledge from the projects. In knowledge management there are two basic strategies for storing knowledge (Hansen, Nohria, Tierney, 1999). The codification strategy is based on codifying the knowledge and storing it in artifacts and databases where it can be accessed. In the personalization strategy, the knowledge is tied to persons who develop it and it is shared by personal interaction. In the codification strategy the firms do big investments in information technology, which enable them to gather, codify and transfer the formal knowledge into documents and reports. In the personalization strategy the companies have moderate investment in information technology, they are more interested in sharing knowledge between people.

The projects interact with knowledge base of the firm in three principal ways:

1. Knowledge mobilization. Because even the existing knowledge of the firm is not always sufficient to meet project objectives, projects often have to act to mobilize and absorb knowledge from the wider environment;
2. Knowledge creation. Projects often create new knowledge. This knowledge may take several different forms depending on whether it is embodied in new products and services, designed into new processes or institutionalized as new practices. This new knowledge may be created both directly as one of the deliverables from the project, and indirectly through the learning involved in achieving that deliverable;
3. Knowledge integration. Project implementation often requires combining skills and ideas from disparate sources. In many instances, this combination is short-term and project-specific. In other words, knowledge is combined to serve the goals and deliverables of the project, but is thereafter allowed to disperse. In some instances, however, the combination produces a synthesis that is of long-lasting value to the organization.

Investment

Both project management and knowledge management disciplines need investment and demand results. While a project size determines the resources and investment needed, investment on project management within an organization depends on the goals of project performance excellence set by the organization. The scope - what we intend to accomplish - of knowledge management determines its investment needs. For successful implementation

of project management and knowledge management, we need to make changes in policies, practices, and procedures train people at all levels make changes to accounting and finance control systems. While project management demands project-based finance and cost control mechanisms, knowledge management introduces innovative cost measuring concepts such as recognizing and accounting for intellectual capital.

CONCLUSIONS AND IMPLICATIONS TO MANAGERS

In such a changing environment modern organizations have to react fast and be flexible, so organizing by projects is on a strong increase. They need to use knowledge management in their projects to manage knowledge such as other tangible resources. In different phases of projects, types of knowledge and involved people and varieties and amount of information need special policies and tasks for management. Knowledge creation can be seen in all phases. According to the authors integrating knowledge management with project management could be desirable and result-oriented because the integration improves project management performance and meets its objectives of time, cost, performance, and customer satisfaction more effectively. There can be several examples highlighting the benefits of integrating knowledge management within project management. Utilizing actual cost data and earned value data of previously executed projects to improve project cost estimating is an example of how a knowledge management concept of learning can help improve project management performance. Knowledge management can enhance the project manager's activities by being better able to leverage knowledge internally and externally through improved knowledge sharing techniques among the project team.
It is important that project-based organizations progress their knowledge management initiatives. This means:

- Ensuring that the organizations start to explicitly identify their knowledge assets and knowledge management related processes;
- Ensuring that the organization starts to control and manage these assets and processes;
- Ensuring that professionals in the organization are aware of the importance of the organization's knowledge assets and are aware of existing knowledge management related processes.

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SYNERGETIC EFFECTS OF PRODUCT TRAINING AND TRAINING TRANSFER FACTORS ON MARKETING MIX - CASE STUDY ON DOMESTIC APPLIANCE INDUSTRY

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ABSTRACT

In today's rapidly changing market and technological environment, manufacturing companies often raise questions about the most efficient way of product commercialization. In times of global crisis and situations of increasingly competitive struggles, product managers should take proactive product strategy with the potential of far-reaching effects in the future. It seems that product trainings also play a crucial role. Product trainings allow all actors participating in marketing mix related processes to acquire appropriate knowledge about product and its components. They increase productivity and flexibility, enhance work skills and influence the product management efficiency. Results of a research among Slovenian domestic appliance companies show a direct impact of a combination of trainings and training transfer factors on marketing mix. We believe that support provided by product managers and supervisors strongly impacts the sales revenue.

Keywords: product management, training, training transfer factors, marketing mix

INTRODUCTION

In the last decade domestic appliance industry is facing with a challenge of explosive demand for new and improved products as well as the availability of new technologies for production and delivery of such products which generates additional demands on the system (O'Connell, 1996). This situation accelerates the rate of a change and it produces an "evolved" system which attempts to respond to changes on marketplace (Katsanis and Pitta, 1995). The product and technology complexity which is actually the base for communication with customers, addresses external and internal marketing needs as well. Therefore many companies are of the opinion that product training is a top priority for them (Neff, 2002). Despite the importance of the role product managers have for the marketing function and for new product introduction, there has been little research conducted on the matter of product managers' training.

TRAINING

Training is defined as the systematic development of skills that individuals need to perform their work (Miglič, 2002). Individuals should take their own responsibility for their professional development but realise their learning needs in partnership with their colleagues at work and their direct superiors using different teaching methods (Torrington, Hall and Taylor, 2008). Armstrong (2003) and Torrington et al. (2008) identify a range of different approaches to training. They state that the training may be based on different

methods of teaching – both off-the-job teaching methods (formal education, consultancy courses, outdoor-type courses, in-house courses, dramas and improvisations, role-plays, simulations etc.) as well as on-the-job teaching methods (instructions, mentoring, self-development, self-development teams, the use of learning logs and learning contracts, e-learning, blended learning etc.)

The volume of trainings in an organisation relates to the degree of uncertainty and unpredictability of the products, markets and R&D (Blandy et al., 2000). By means of various trainings organisations reduce the possibilities of unpleasant surprises and enhance the well-being of their employees (Armstrong, 2003). Trainings increase the value of individuals in the labour market; enhance their satisfaction with the current work and thus their loyalty to the organisation (Torrington et al., 2008). Consequently training reduces staff turnover (Blandy et al., 2000) and increases organisation's revenues and profits (Bontis, 2003). Because of these potential benefits a significant rise in the amount of training inside the organisations (Campbell, 2006; Sugrue, 2003) and in the number of the participants could be expected (Blandy et al., 2000).

Dechawatanapaisal and Siengthai (2006) consider that adequate opportunities for training should be offered to the employees. Garvin, Edmondson, and Gino (2008) say as well that all the employees in an organisation should receive periodic training. In particular, they highlight the importance of training for new employees and training in cases of special events in the organisation and emphasise the need to train employees when new business or work initiatives emerge, as well as in cases of employees' transfer to other posts or changes to the content of existing jobs. Jarvis, Holford, and Griffin (2006) consider that training in the past was highly stratified. Mostly the upper levels of organizational hierarchies benefited from the training, and on the other side the lower levels very little or nothing. Situation in the last 50 years has changed (Trunk Širca et al., 2009). Blandy et al. (2000) for example, reported that the majority of organisations train 80-85% of their employees. On the other hand problems in smaller organisations due to weak attitude towards training are still present. Managers in small businesses are often unaware of the potential benefits of training (Storey and Westhead, 1997) and afraid that their well trained staff could be head-hunted by bigger and more powerful corporations (Carter and Jones-Evans, 2006).

TRAINING TRANSFER FACTORS

Practice and theory of training acknowledge a variety of so called training transfer factors. These factors encourage transfer of knowledge acquired within a certain training context to a certain work context and thus positively contributing to the performance of individual employees and an organisation as a whole (Holton III, Hsin-Chih, and Naquin, 2003). The causal link between changes in behaviour and performance of individuals and organisational performance is anticipated also by Kirkpatrick's training evaluation model (Kirkpatrick 1998). Regarding the training transfer some authors emphasise the need for systematisation of training activities, for careful planning of training events and for the use of monitoring activities. Externalisation and recording of tacit knowledge seems to be important as well, and the use of adequate teaching methods including reflexive thinking, team-based approaches to learning, practical work tasks and project work (Bader and Bloom, 1995).

Baldwin, Magjuka, and Loher (1991) among the others, note that performing some specific managerial activities before the training could have a relevant influence on the perception of the importance of training, on learning motivation and later on also on training transfer. Standpoints of managers and superiors and their actions can be a significant signal for the employees since they affect not only the process of learning but individual and organisational behaviour as well (Wieland Handy, 2008). So, we certainly need to emphasise the meaning of training support provided by both work colleagues (peers) and direct superiors in an organisation.

THE ROLE OF PRODUCT TRAINING IN COMPANIES

Meža (2009) defines product management as a kind of a messenger of a market. It directly transfers clear information about a market and market happenings to different departments in a company which need such information to make their business decisions. Nowadays, in the times of severe competition and constant price pressures, this should be a permanent activity of product managers to care for cost reduction of product cycles.

Each product in a company has to be closely related to the wishes and needs of the customers and to the market as a whole. It should also be compared to the competitive products on the market to see and stress out its advantages and to solve possible problems related to its weaknesses. The product position on the market can be defined as the combination of product quality and its characteristics perceived by the customers. Adequate product positioning on the market is necessary in order to successfully carry out company strategy.

Summing up the activities of the product management, the product managers are responsible for:

- collecting and analysis of market information, information about competitors and the perception of new trends,
- working on development of new programs,
- supporting the sales department when new products, product families and product lines are launched onto the market,
- price positioning and setting the prices for new products,
- performance monitoring of a product group.

Product management core activities are by no means focused on a product and/or on management activities. They are related to direct participation in project development and in planning of new products. The outcomes of the product management work can be judged by the product quality or the level its success. Certainly, we should note, that there are some products which are more likely to be successful on the market, and there are others, which might be unsuccessful as well.

On the other hand, domestic appliance industry is facing a crisis nowadays. Some authors (Meža, 2009) suggest variety of possibilities to solve or even prevent such product crises. Product management and product training could play an important role in avoiding and preventing potential product crises resulting in inefficient market communication, weak commercialization of novelties/changes (due to poor advertising start and inadequate

advertising strategy). Therefore product training is inherently related to cycle time reduction activities. When considering trainings for new salespeople and customer about product, the implicit assumption is, that the benefits of such training should be improved product sales, better product introduction on market, improved brand image, etc. By our opinion product training in the industry of domestic appliances plays an important role.

THE MODEL OF PRODUCT TRAINING

Product managers should understand that they have to use multiple marketing tools (product, price, place, promotion) to enhance the quality and relevance of product training. Actually, the very well known 4Ps should represent an important tool for influencing customers' choices (Kotler, 2009). On the other hand, from the customer's perspective, each marketing tool is supposed to deliver a customer benefit ("C") (figure 1). We propose to use these two approaches in a way which enables the product training to play an important, active role in connecting 4Ps and consumer's 4Cs and consequently in the customer value creation. In general, product training should be designed in a way to affect all the categories of 4Cs customer needs, customers' perception of costs, convenience/choices customer have and communication possibilities for maximizing the possibilities for influencing the customer choices.

Product training should be based on proper training content and on appropriate training methods as well. When designing the training, these two ingredients should be considered at the same time and should be carefully discussed with product managers as well. We propose the following four-outcome measurement schema for designing the product training:

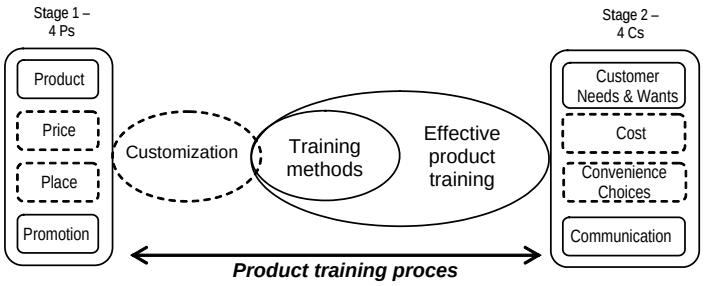

Figure 1: Model of Product training system.

As already mentioned, at the same time as the training content is outlined and the relations between 4Ps and 4Cs identified, training methods should be selected as well. In our case a training method is a strategy or tactics that a product manager (trainer) uses to deliver the message to the participants of the training so that the product training achieves its objectives. There are, however, a variety of techniques for conveying information to 4C and therefore one or a mix of several training methods can be used. These are shortly described in table 1.

Table 1: Training methods for Product training (adapted from Carey, 1999).

Training method	Description
Lecture	• Mostly an oral presentation, but may be supplemented with visual aids or handouts. • The technique is generally confined to presenting only the expert's point of view. • Often used because it is easier to organize and a great deal of information can be presented in a short period of time. • Useful when there are large groups of trainees.
Lecture/Discussion	• Variation of the lecture where the trainer increases trainee participation through facilitation of discussion at set times during the session. • Discussion is often initiated through the use of questions. • Trainer must plan the discussion and carefully choose the questions to lead the discussion
Demonstration	• Oral explanations combined with visual activities. • Method demonstrations show processes, concepts and facts and are especially effective in teaching a skill that can be observed. • A result demonstration shows the outcome of some practice or innovation, such as unique sales features, product operation etc.
Group discussion	• Trainer leads the trainees as a group through a discussion of a given topic. • May or may not be preceded by a short explanatory lecture.
Symposium	• A series of lectures presided over by a moderator. • Allows for the presentation of several points of view or several related topics.
Panel	• A dialogue among several experts sitting in front of the room. • A moderator coordinates the discussion. • Differs from a symposium because panel members have an opportunity to discuss and interact with each other's ideas and views.
Forum	• Following one or more presentations, the audience interacts and discusses the topic(s), bringing up a wider range of views
Discussion groups	• Involves every member of the audience in a small group (4 to 20 people per group). • Groups may have a pre-selected or self-elected leader. • The groups may be given a specific topic or asked to develop a list of problems, issues, priorities, questions, etc. and report back to the main group. • Discussion groups encourage/allow everyone to participate, even if the audience is large. • Groups should be monitored to insure that one person is not dominating the activities.
Case studies	• Information is given to the trainees detailing a specific situation or problem and the trainees are assigned (as individuals or discussion groups) the task of making recommendations for the most appropriate action to solve the problem. • Introduces a practical aspect to the training environment and creates a problem solving situation similar to that many trainees may face after returning to work.
Field visits	• A visit to an organization or workplace, such as a production plant or trade show, that demonstrates the practical application of the ideas under discussion. • Care must be taken that the place to be visited is aware of the objectives of the field trip. • Adds a practical aspect to the training • Trainees need to be properly prepared for the visit and should be encouraged to make specific observations.

METHODOLGY

To evaluate the product training issues incorporated in marketing mix categories, a study was commissioned. Project managers in 7 companies were chosen as product training providers. The purpose of the research and data collection was to find actual and relevant training methods for different 4Ps categories (see table 2) described and presented in the Model of Product training system (see fig. 1) and also key contents which are relevant for each of the 4Ps categories and consistent with the chosen methods of teaching.

We developed an interview approach to find out which training methods are relevant to each one of the 4Ps categories. The target population of the training were customers. The results of the study are presented in table 2

Table 2: Training methods utilized by 4P components.

Element of 4 P	Training method	Content
PRODUCT		
Assortment	Lecture, Lecture/Discussion, Field visits	Workbooks/manuals, Market/customer knowledge
Quality	Lecture/Discussion, Demonstration, Case studies, Field visits	Workbooks/manuals, Company policy
Design	Lecture/Discussion, Field visits, Group discussion, Symposium, Panel, Forum, Discussion groups	Product education Team work
Feature	Lecture, Lecture/ Discussion, Demonstration , Field visits	Workbooks/manuals, Product education
Brand	Lecture/Discussion, Group discussion, Panel, Forum, Field visits,	Workbooks/manuals, Product education, Team work, Sales techniques
Service/Warranty	Lecture/ Discussion, Group discussion	Workbooks/manuals, Company policy
PRICE		
Price-value	Lecture/Discussion, Demonstration, Discussion groups, Field visits	Product education, Workbooks/manuals, Market/customer knowledge
Discount	Discussion groups, Field visits	Team work, Sales techniques
Payment terms	Discussion groups, Field visits	Sales techniques, Company policy
PLACE/DISTRIBUTION		
Sale channels	Discussion groups, Field visits	Sales techniques, Company policy, Market/customer knowledge
Market share	Lecture/Discussion, Demonstration, Discussion groups, Field visits	Market/customer knowledge, Company policy
Public relation	Lecture/Discussion, Symposium, Panel, Forum, Field visits	Product education, Workbooks/manuals, Market/customer knowledge, Company policy
PROMOTION		
Advertising	Lecture/Discussion, Demonstration, Discussion groups, Field visits	Workbooks/manuals, Product education, Sales techniques, Company policy

After the best training methods and training contents had been gathered, we focused our research into finding out which training methods should be used at each stage of New Product Introduction (NPI) project phases (see table 3). The majority of the training methods used in different phases of NPI are participant focused demanding high level of their participation. This is an important guideline for the organisation of such events because such approaches to product trainings require trainers with appropriate social skills.

Table 3: Training methods provided in NPI project phases.

Phase of NPI project	Training method used	Project objective
Scoping phase	Case studies, Field visits, Group discussion	Scope project & develop concepts
Feasibility phase	Case studies, Case studies, Group discussion	Detailed investigation & prototyping
Justification phase	Group discussion, Panel, Demonstration	Develop business case
Development phase	Group discussion, Panel	Product development
Manufacturing phase	Group discussion, Panel	Operational Ram-Up
Launch phase	Lecture/Discussion, Demonstration, Case studies, Field visits, Group discussion, Symposium, Panel, Forum, Discussion groups	Commercial phase

CONCLUSIONS

Product training seems to be an important mechanism for introduction of new products in domestic appliance industry. This is especially important because the competition in this industry is getting stronger nowadays. In our paper we recognise a variety of training methods which influence customers' needs, lower their perceptions of costs, enhance their convenience/choices and communication possibilities. They stem from marketing mix components and have the power for maximizing the possibilities for influencing the customer decisions. The training methods should be related to training contents as well. The findings of our research are especially important to product managers who are usually responsible for organising such trainings.

In this paper, when referring to the Model of Product training system, we recognize the training methods and contents which could help the companies to successfully introduce new products. In the literature there aren't practically any studies examining such issues – studying the causal links or correlations between the new product introduction and training. Therefore, we recommend conducting further research related to product trainings, because the findings may have a significant impact on the strategies/tactics of new product introduction.

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ASSESING CORRELATED RISK USING THE MULTIVARIATE PROCESS INCAPABILITY INDICES

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ABSTRACT

Process capability indices have been widely used in industry today since they provide quantitative measures for evaluating process performance. Instead of using process capability index, the process incapability index C_{pp} has an advantage of separating the information of process accuracy and precision for a symmetric tolerance. Using C_{pp} process incapability index, the process performance and its risk level can easily be understood by quality practitioners. Recently, a new process incapability index C''_{pp} (s,t) is developed based on the desirability function to correctly measure the process performance for an asymmetric tolerance.

In this paper, due to the fact that the quality of an industrial product is determined by two or more interrelated quality characteristics, we propose new multivariate incapability process indices by taking the correlation among multiple quality characteristics into account. Analogous to univariate process incapability index, the multivariate process incapability index can be viewed as an extension of the univariate process incapability index and thus the manufacturing/environmental risk for a multivariate process can be evaluated accordingly. The major advantage of using the multivariate process incapability indices is that the correlated risk for a multivariate process and its expected losses can be evaluated in a more precise way. Finally, the correlated risk assessment using the new multivariate incapability indices and their associated interval estimates is further demonstrated by two numerical examples.

Keyword: multivariate process incapability indices, desirability function, symmetric and asymmetric tolerances, correlated risk assessment.

INTRODUCTION

In today's business environment, it is becoming more and more important for companies to evaluate the risks associated with their processes to improve the product quality and system safety as well as to reduce hazardous waste from their facilities. Traditionally, engineers perform process capability studies to analyze the performance of key quality characteristics. Quality improvement actions will be taken if the process is not capable of meeting specifications. Statistical process control tools, such as univariate and multivariate process capability indices have been widely employed in the assessment of manufacturing performance. According to Ayyub (2003), risk is commonly evaluated as the product of likelihood of failure occurrence and its impact, namely, RISK= LIKELIHOOD$\times$ IMPACT. This equation presents risk as an expected value of loss or an average loss. There are several methods currently being used for risk assessment in the manufacturing and chemical process industries. The most well known technique for quantitative risk assessment is failure mode and effect analysis (FMEA), as described in Montague (1990) and Ayyub (2003). This involves identifying each process step that may fail, then assigning rankings for occurrence, severity, and detectability. The "occurrence ranking" indicates how likely a failure is considered to occur (where higher scores correspond to higher probabilities), and is related to the process capability indices. The "severity ranking" shows the potential impact of a failure. The "detectability ranking" indicates how likely it is that a failure can go undetected until its full impact materializes. The three rankings are then multiplied, and higher total scores indicate higher risk priority number (RPN). Apparently, the ranking is purely subjective, and determined by quality practitioners.

Process capability indices (PCIs), on the other hand, have been widely used in industry today. They provide quantitative measures of process performance and thus lead to the direction of quality improvement. Instead of using process capability index, the process incapability index, $C_{pp} = (\mu - T)^2/D^2 + \sigma^2/D^2$ where $D = \min(D_l, D_u)/3$, $D_l = T - LSL$, $D_u = USL - T$, LSL is the lower specification limit, USL is the upper specification limit, T is the target value, μ is the process average and σ is the process standard deviation, introduced by Greenwich and Jahr-Schaffrath (1995) has the advantage of separating the information of accuracy and precision for symmetric tolerances. If the key characteristic of a process Y has mean μ and variance σ^2, then the expected valued of square loss, $E(Y-T)^2$, equals to $(\mu - T)^2 + \sigma^2$ where T is target value. Thus, according to Ayyub's (2003) definition of risk (i.e. Risk can be treat as an expected value of loss or an average loss), the process incapability index C_{pp} can be treated as a

standardized risk index since $C_{pp} = E(Y-T)^2/D^2$. Using the process incapability indices, the process risk level can easily be understood by quality practitioners. In addition to symmetric tolerances, asymmetric tolerances are frequently encountered in aerospace and auto industries. To measure the process performance for an asymmetric tolerance, the process incapability index C''_{pp} was proposed by Chen (1998). However, those process incapability indices are inappropriate since they can't correctly reflect the true process incapability for asymmetric tolerance. Pan and Lee (2009) proposed a new univariate process incapability index $C''_{pp}(s,t) = C''_{ia}(s,t) + C_{ip}$ using the concept of desirability function, which can properly reflect the actual non-conforming rate.

Recently, the serious ecological problems caused by an pollution and other contaminations, almost all the Environmental Protection Agencies (EPA) around the world have imposed regulations or laws, such as air pollution control act to reduce and control air pollution problems. Among them, the NO_x and SO_x emission and their potential loss at a chemical company located in Kaohsiung county of Taiwan (see Pan and Chi, 2008) is a good practical example for the application of correlated risk assessment. Moreover, due to the fact that the quality of a process output is often measured by the joint level of several correlated process quality characteristics, it is useful to develop a multivariate process incapability index to correctly reflect the correlated risk in terms of process inaccuracy and process variation. The major advantages of using the multivariate process incapability indices is that the correlated risk for a multivariate process and its expected losses can be evaluated in a more precise way. Thus, it is necessary to develop accurate multivariate process incapability indices for assessing the correlated risk occurred in either a manufacturing or environmental multivariate process.

LITERATURE REVIEW

Greenwich and Jahr-Schaffrath (1995) proposed an incapability index called C_{pp}, which can be considered as a simple transformation of the process capability index C^*_{pm}.

$$C_{pp} = \left(\frac{1}{C^*_{pm}}\right)^2 = \left(\frac{\mu - T}{D}\right)^2 + \left(\frac{\sigma}{D}\right)^2 = C_{ia} + C_{ip}, \qquad (1)$$

where $C_{ip} = (\sigma / D)^2$, $C_{ia} = ((\mu - T)/D)^2$ and $D = \min(D_l, D_u)/3$. The advantage of using C_{pp} index is that it provides separate information concerning the process accuracy and

precision, which is not available in C_{pm}^{*} index. Therefore, this information separation is highly beneficial because it indicates to what degree the process inaccuracy contributes the process being incapable of meeting the specification.

Chen (1998) found that C_{pp} index is incorrect for asymmetric tolerances. In order to overcome the drawback, he proposed the $C_{pp}^{"}$ index as shown in Equation (2) to deal with asymmetric tolerances.

$$C_{pp}^{"} = \left(\frac{A}{D}\right)^2 + \left(\frac{\sigma}{D}\right)^2 = C_{ia}^{"} + C_{ip}, \tag{2}$$

where $D = \min(D_l, D_u)/3$, $A = \max\{(\mu - T)d/D_u, (T - \mu)d/D_l\}$, $d = (USL - LSL)/2$, $D_u = USL - T$ and $D_l = T - LSL$.

Pan and Lee (2009) further showed that Chen's process incapability index is inappropriate since it can't properly reflect the actual non-conforming rate for asymmetric tolerance. Hence, they proposed a new univariate process incapability index $C_{pp}'''(s,t) = C_{ia}'''(s,t) + C_{ip}$ using the concept of desirability function. Due to the fact that manufacturing risks are inversely proportional to the distances between the target and specification limits, their relationship can be reflected by an appropriate selection of s and t values. To facilitate the assessment of manufacturing risks, a decision rule for determining s and t is derived. Pan and Lee (2009) proved that $C_{pp}'''(s,t)$ index is more accurate than C_{pp} and C_{pp}''' indices in assessing the manufacturing risks.

THE DEVELOPMENT OF A MULTIVARIATE PROCESS INCAPABILITY INDEX

To develop a multivariate process incapability index, we first assume that the two key quality characteristics are independent. According to the definition of C_{ia}''' index, it can be shown by using the following indicator function:

$$C_{ia}''' = 1_{\{\mu \le T\}}(\mu) \left(\frac{T - \mu}{D_l}\right)^2 \frac{d^2}{D^2} + 1_{\{\mu > T\}}(\mu) \left(\frac{\mu - T}{D_u}\right)^2 \frac{d^2}{D^2}, \tag{3}$$

where indicator function 1_A is defined as

$$1_A(x) = \begin{cases} 1, & x \in A \\ 0, & x \in A^c. \end{cases} \tag{4}$$

Since Equation (3) has a quadratic form, a matrix presentation of the bivariate process incapability index MC_{ia} can be defined as

$$MC_{ia}=\begin{bmatrix} \mu_1 - T_1 \\ \mu_2 - T_2 \end{bmatrix}'\begin{bmatrix} \frac{1_{\{\mu_1>T_1\}}d_1^2}{D_1^2 D_{1u}^2}+\frac{1_{\{\mu_1\le T_1\}}d_1^2}{D_1^2 D_{1l}^2} & 0 \\ 0 & \frac{1_{\{\mu_2>T_2\}}d_2^2}{D_2^2 D_{2u}^2}+\frac{1_{\{\mu_2\le T_2\}}d_2^2}{D_2^2 D_{2l}^2} \end{bmatrix}\begin{bmatrix} \mu_1 - T_1 \\ \mu_2 - T_2 \end{bmatrix}, \quad (5)$$

where μ_j, T_j, USL_j and LSL_j, $j = 1, 2$, are the process average, target value, upper and lower specification limit of *j*th key quality characteristic respectively, $D_j = \min(D_{jl}, D_{ju})/3$, $D_{jl} = T_j - LSL_j$ and $D_{ju} = USL_j - T_j$. By matrix computation, Equation (5) can be rewritten as

$$\begin{aligned} MC_{ia} &= (\mu_1 - T_1)^2\left[\frac{1_{\{\mu_1>T_1\}}d_1^2}{D_1^2 D_{1u}^2}+\frac{1_{\{\mu_1\le T_1\}}d_1^2}{D_1^2 D_{1l}^2}\right]+(\mu_2 - T_2)^2\left[\frac{1_{\{\mu_2>T_2\}}d_2^2}{D_2^2 D_{2u}^2}+\frac{1_{\{\mu_2\le T_2\}}d_2^2}{D_2^2 D_{2l}^2}\right] \\ &= C''_{ia1} + C''_{ia2} \end{aligned}, \quad (6)$$

where C''_{iaj} is the C''_{ia} indices of *j*th key quality characteristic, $j = 1, 2,$ respective. It is straightforward to extend Equation (6) to a general case in which the product has p key quality characteristics. Thus, the multivariate process inaccuracy index MC_{ia} for p characteristics can be defined as

$$MC_{ia} = (\boldsymbol{\mu} - \mathbf{T})'\mathbf{C}_{ind}^{-1}(\boldsymbol{\mu} - \mathbf{T}), \quad (7)$$

where $\boldsymbol{\mu} = [\mu_1, \ldots, \mu_p]'$ is the vector of the process average and $\mathbf{T} = [T_1, \ldots, T_p]'$ is the target vector and $\mathbf{C}_{ind}^{-1}$ is a cost matrix that be defined as

$$\mathbf{C}_{ind}^{-1} = \begin{bmatrix} \frac{1_{[\mu_1>T_1]}d_1^2}{D_1^2 D_{1u}{}^2}+\frac{1_{[\mu_1\le T_1]}d_1^2}{D_1^2 D_{1l}{}^2} & 0 & \cdots & 0 & 0 \\ 0 & \ddots & & & 0 \\ \vdots & & \frac{1_{[\mu_i>T_i]}d_i^2}{D_i^2 D_{iu}{}^2}+\frac{1_{[\mu_i\le T_i]}d_i^2}{D_i^2 D_{il}{}^2} & & \vdots \\ 0 & & & \ddots & 0 \\ 0 & & \cdots & 0 & \frac{1_{[\mu_P>T_P]}d_P^2}{D_P^2 D_{Pu}{}^2}+\frac{1_{[\mu_P\le T_P]}d_P^2}{D_P^2 D_{Pl}{}^2} \end{bmatrix}$$

If we consider that the p quality characteristics are independent, then the multivariate process inaccuracy index, MC_{ia}, has an additive property, i.e.

$$MC_{ia} = \sum_{j=1}^{p} C''_{iaj}, \quad (8)$$

where C''_{iaj} is the C''_{ia} index of the *j*th key quality characteristic. The additive property in Equation (8) has a meaningful interpretation under the assumption of independence: the C''_{ia} index provides information about the process inaccuracy while only depending on process average μ, the location parameter. Thus, we can conclude that the multivariate process incapability index in Equation (8) is correct.

Next we consider the matrix presentation of the imprecision index MC_{ip} of a bivariate process which is similar to Equation (7).

$$MC_{ip} = \left| \begin{bmatrix} (D_1^2)^{-1} & 0 \\ 0 & (D_2^2)^{-1} \end{bmatrix} \begin{bmatrix} \sigma_1^2 & 0 \\ 0 & \sigma_2^2 \end{bmatrix} \right|, \tag{9}$$

where $|\cdot|$ is a determinant notation, σ_j^2, T_j, USL_j and LSL_j are the process variance, target value, upper and lower specification limit of *j*th key quality characteristic, $j = 1, 2$, $D_j = \min(D_{jl}, D_{ju})/3$, $D_{jl} = T_j - LSL_j$ and $D_{ju} = USL_j - T_j$. By a matrix computation, Equation (21) can be rewritten as

$$MC_{ip} = \left| \begin{bmatrix} \frac{\sigma_1^2}{D_1^2} & 0 \\ 0 & \frac{\sigma_2^2}{D_2^2} \end{bmatrix} \right| = C_{ip1} C_{ip2}, \tag{10}$$

where C_{ipj} is the *j*th index C_{ip} of key quality characteristic, $j = 1, 2$. Equation (10) can be extend to a general case in which the product has p key quality characteristics. Thus, the multivariate process imprecision index MC_{ip} for p characteristics can be written as:

$$MC_{ip} = |\mathbf{D}_{ind}^{-1} \boldsymbol{\Sigma}|, \tag{11}$$

where $\boldsymbol{\Sigma}$ is the variance-covariance matrix and $\mathbf{D}_{ind}$ is defined as

$$\mathbf{D}_{ind} = \begin{bmatrix} D_1^2 & 0 & \cdots & & 0 \\ 0 & \ddots & & & \\ \vdots & & D_j^2 & & \vdots \\ & & & \ddots & 0 \\ 0 & & \cdots & 0 & D_P^2 \end{bmatrix}$$

Now we consider p quality characteristics under the independent assumption, the

multivariate process imprecision index, MC_{ip}, has the following multiplicative property.

$$MC_{ip} = \prod_{j=1}^{p} C_{ipj}, \tag{12}$$

where C_{ipj} is the C_{ip} index of the *j*th key quality characteristic. The multiplicative property in Equation (12) also has a meaningful interpretation under the assumption of independence: the C_{ip} index provides information about process imprecision while only depending on the process variance σ^2, scale parameter. Thus, we conclude that the imprecision index of a multivariate process in Equation (12) is correct.

Based on Equations (7) and (11), the multivariate process incapability index can be written as

$$MC''_{pp} = (\boldsymbol{\mu} - \mathbf{T})'\mathbf{C}_{ind}^{-1}(\boldsymbol{\mu} - \mathbf{T}) + |\mathbf{D}_{ind}^{-1}\boldsymbol{\Sigma}| = MC''_{ia} + MC_{ip}, \tag{13}$$

To develop a general index for evaluating correlated risk, we relieve the independent assumption to a dependent one and consider the following quadratic loss function proposed by Pignatiello (1993) that has several correlated quality characteristics. Pignatiello (1993) proposed a quadratic loss function as shown in Equation (14) for manufactured products that has several correlated quality characteristics.

$$loss(\mathbf{Y}) = (\mathbf{Y} - \tau)'\mathbf{C_q}(\mathbf{Y} - \boldsymbol{\tau}), \tag{14}$$

where $\mathbf{Y}$ is the vector of quality characteristics, $\boldsymbol{\tau}$ is the vector of target values and $\mathbf{C_q}$ is a positive definite cost matrix. When $\mathbf{C_q}$ is a diagonal matrix, the loss function is the sum of p single-response quadratic loss functions. For non-diagonal $\mathbf{C_q}$ matrices, the off-diagonal elements are related to the incremental losses that are incurred when pairs of quality characteristics are simultaneously off-target. In the bivariate case, the loss can be written as

$$\begin{aligned} loss(\mathbf{Y}) &= \begin{bmatrix} y_1 - \tau_1 \\ y_2 - \tau_2 \end{bmatrix}' \begin{bmatrix} c_{11} & c_{12} \\ c_{12} & c_{22} \end{bmatrix} \begin{bmatrix} y_1 - \tau_1 \\ y_2 - \tau_2 \end{bmatrix} \\ &= c_{11}(y_1 - \tau_1)^2 + c_{22}(y_2 - \tau_2)^2 + c_{12}(y_1 - \tau_1)(y_2 - \tau_2), \end{aligned} \tag{15}$$

where y_i is the *i*th key quality characteristics, τ_i the *i*th target value for quality characteristics and c_{ij} is the cost parameter. The first two terms on the right hand side in Equation (16) are the univariate quadratic loss function values. The last term is non-zero only when both quality characteristics are off-target and $c_{12} \neq 0$. The coefficient c_{12} is related to the additional incurred loss when both y_1 and y_2 are off-target. Hence, we can modify

the $\mathbf{C}_q$ matrix in Equation (15) to develop an inaccuracy index of a multivariate process. Based on Pignatiello's (1993) multiple response loss function, a multivariate process inaccuracy index, without an independent assumption, can be defined as

$$MC_{ia} = (\boldsymbol{\mu} - \mathbf{T})'\mathbf{C}^{-1}(\boldsymbol{\mu} - \mathbf{T}), \tag{16}$$

Then, the diagonal and off-diagonal entries of matrix $\mathbf{C}$ can be written as:

$$1_{\{\mu_i \le T_i\}} c_{il}^2 + 1_{\{\mu_i > T_i\}} c_{iu}^2$$

and

$$\rho_{ij}(1_{\{\mu_i \le T_i\}} 1_{\{\mu_j \le T_j\}} c_{il} c_{jl} + 1_{\{\mu_i \le T_i\}} 1_{\{\mu_j > T_j\}} c_{il} c_{ju} + 1_{\{\mu_i > T_i\}} 1_{\{\mu_j \le T_j\}} c_{iu} c_{jl} + 1_{\{\mu_i > T_i\}} 1_{\{\mu_j > T_j\}} c_{iu} c_{ju})$$

where $1_{\{\mu_i \le T_i\}}$ is the indicator function, $c_{il} = (D_i D_{il})/d_i$ and $c_{iu} = (D_i D_{iu})/d_i$, $i = 1, \ldots, p$, are the cost parameters and ρ_{ij} represents the correlation coefficient between *i*th and *j*th quality characteristics. The coefficients $c_{il}c_{jl}$, $c_{il}c_{ju}$, $c_{iu}c_{jl}$ and $c_{iu}c_{ju}$ are related to the additional incurred loss when both the *i*th and *j*th quality characteristics are off-target.

Using the concept of the univariate process capability index C_p, the MC_p index proposed by Taam et al. (1993) will be equal to 1 if the manufacturing process region falls completely within an engineering tolerance region and the manufacturing process follows a multivariate normal distribution. Pan and Lee (2010) proved that the calculation of the MC_p index proposed by Taam et al. (1993) can be simplified to:

$$MC_p = |\boldsymbol{\rho}|^{-1/2}, \tag{17}$$

where $\boldsymbol{\rho}$ is a correlation matrix. Equation (17) implies that the value for the MC_p index might be greater than 1 (an overestimation occurs) since the determinant for the correlation matrix is between 0 and 1. In other words, the value of the MC_p index will be greater than 1 if the quality characteristics are not independent, which results in an overestimation of the true process performance. Similarly, for the $MC_{pm} = MC_p/D$ index proposed by Taam et al. (1993), the same drawback could occur when the multiple quality characteristics are not independent. Thus, by adopting similar multivariate control region concepts shown in Montgomery (2001), we further revise Taam's modified engineering tolerance region so that the shape of the ellipsoid within the engineering tolerance region can be flexibly adjusted by the correlation of multiple quality characteristics. The relationship between

Taam's modified regular tolerance region and our revised slanted tolerance region for a bivariate quality characteristic is illustrated in Figure 1.

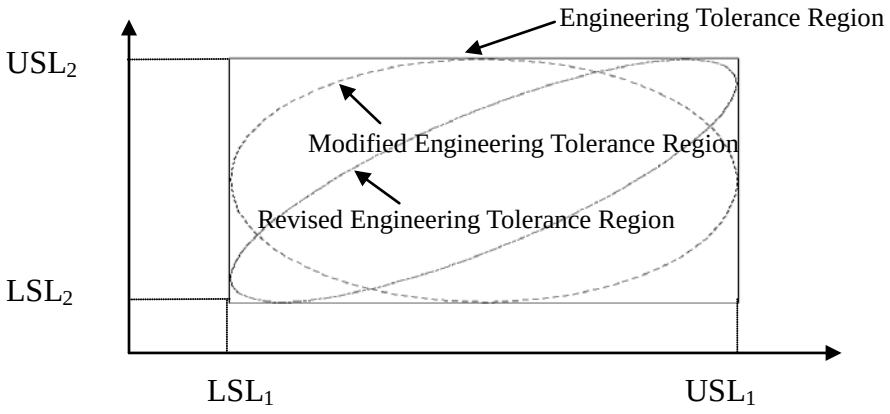

Figure 1: Relationship between Taam's modified region and our revised engineering tolerance region.

To overcome the drawback of overestimation using the MC_p and MC_{pm} indices, a revised engineering tolerance region is proposed as below:

$$E_{d_E,\mathbf{A}^*,\mathbf{T}} = \{\mathbf{X} \in \mathbf{R}^p | (\mathbf{X}-\mathbf{T})'(\mathbf{A}^*)^{-1}(\mathbf{X}-\mathbf{T}) = d_E^2\}, \tag{18}$$

where the elements of matrix $\mathbf{A}^*$ are given by

$$\rho_{ij}\left(\frac{USL_i - LSL_i}{2d_E}\right)\left(\frac{USL_j - LSL_j}{2d_E}\right) \quad i,j = 1,\ldots,p, \tag{19}$$

$\mathbf{T}$ is the target vector, ρ_{ij} represents the correlation coefficient between the *i*th and *j*th quality characteristics and $(USL_i - LSL_i)$ denotes the *i*th specification width for each side of rectangle circumscribed to the ellipsoid $E_{d_E,\mathbf{A}^*,\mathbf{T}}$. Similar to the MC_{pm} ratio of the two volumes shown in Taam et al. (1993), our proposed multivariate process capability index can be written as

$$NMC_{pm} = \frac{Vol.(E_{d_E,\mathbf{A}^*,\mathbf{T}})}{Vol.(E_{d_E,\mathbf{\Sigma},\boldsymbol{\mu}})}\left(1 + (\boldsymbol{\mu}-\boldsymbol{T})'\mathbf{\Sigma}^{-1}(\boldsymbol{\mu}-\boldsymbol{T})\right)^{-1/2}$$

Let $d_E^2 = \chi^2_{p,1-\alpha}$ and $\chi^2_{p,1-\alpha}$ is the $100(1-\alpha)$*th* percentile of a chi-square distribution with p degrees of freedom, then the NMC_{pm} index can be rewritten as

$$NMC_{pm} = \frac{|\mathbf{A}^*|^{1/2}}{|\boldsymbol{\Sigma}|^{1/2}} \left(1 + (\boldsymbol{\mu} - \boldsymbol{T})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - \boldsymbol{T})\right)^{-1/2} = NMC_p / D_{ev},$$

where $NMC_p = (|\mathbf{A}^*|/|\boldsymbol{\Sigma}|)^{1/2}$ and $D_{ev} = (1 + (\boldsymbol{\mu} - \boldsymbol{T})'\boldsymbol{\Sigma}^{-1}(\boldsymbol{\mu} - \boldsymbol{T}))^{1/2}$. Notice that the term D_{ev} in NMC_{pm} index denotes a function of Mahalanobis distance between the process mean and target vector and it can be used to measure the process deviation from target $\mathbf{T}$. Furthermore, C_p and C_{pm} indices can be considered as a special case of our NMC_p and NMC_{pm} indices if $p = 1$ and $1 - \alpha = 0.9973$. Based on the concept of univariate process incapability index C_{pp}, the transformation of NMC_p index can be rewritten as

$$\left(\frac{1}{NMC_p}\right)^2 = \frac{|\boldsymbol{\Sigma}|}{|\mathbf{A}^*|}, \tag{20}$$

By a matrix computation, the Equation (20) can be rewritten as below

$$MC_{ip} = |\mathbf{D}_{ind}^{-1}\boldsymbol{\Sigma}| = \frac{|\boldsymbol{\Sigma}|}{|\mathbf{D}_{ind}|}, \tag{21}$$

According to Equations (20) and (21), the matrices $\mathbf{A}^*$ and $\mathbf{D}_{ind}$ have the same structure. We can modify the matrix $\mathbf{D}_{ind}$ in Equation (21) to develop an imprecision index for the multivariate process by considering the correlation among several key quality characteristics. Thus, relieving the independence assumption, the imprecision index for a multivariate process can be defined as

$$MC_{ip} = \frac{|\boldsymbol{\Sigma}|}{|\mathbf{D}|}, \tag{22}$$

where the elements of matrix $\mathbf{D}$ are

$$(\rho_{ij} d_i^* d_j^*)/\chi^2_{p,1-\alpha}, \; i, j = 1, \ldots, p, \tag{23}$$

ρ_{ij} is the correlation coefficient between the *i*th and *j*th quality characteristics, $d_i^* = \min(D_{il}, D_{iu})$, $D_{il} = T_i - LSL_i$, $D_{iu} = USL_i - T_i$ and $\chi^2_{p,1-\alpha}$ is the $(1-\alpha)$th percentile of a chi-square distribution with p degrees of freedom. Based on the results of Equations (16) and (22), the multivariate process incapability index for evaluating the correlated risk can be written as

$$MC_{pp} = MC_{ia} + MC_{ip} = (\boldsymbol{\mu} - \mathbf{T})'\mathbf{C}^{-1}(\boldsymbol{\mu} - \mathbf{T}) + \frac{|\boldsymbol{\Sigma}|}{|\mathbf{D}|}.$$

In order to evaluate the performance of our proposed multivariate process incapability indices, a simulation study has been conducted and random samples with various sample sizes are generated from the multivariate normal distribution $N(\boldsymbol{\mu}, \boldsymbol{\Sigma})$. To evaluate process performance by using our proposed multivariate process incapability indices, five hypothetical bivariate processes listed in Table 1 are considered.

The specifications and target values are assumed to be $(LSL_1, USL_1) = (-3.4393, 3.4393)$, $(LSL_2, USL_2) = (-3.4393, 3.4393)$ and $\mathbf{T} = (0, 0)$.

Table 1: The mean vector and covariance matrix of five bivariate processes.

	Hypothetical bivariate processes				
	I	**II**	**III**	**IV**	**V**
Mean vector ($\boldsymbol{\mu}$)	$\begin{bmatrix}0\\0\end{bmatrix}$	$\begin{bmatrix}0\\0\end{bmatrix}$	$\begin{bmatrix}0\\0\end{bmatrix}$	$\boldsymbol{\Sigma}^{1/2}\begin{bmatrix}1\\1\end{bmatrix}$	$\boldsymbol{\Sigma}^{1/2}\begin{bmatrix}1\\1\end{bmatrix}$
Covariance matrix ($\boldsymbol{\Sigma}$)	$\begin{bmatrix}1 & \rho\\ \rho & 1\end{bmatrix}$	$\begin{bmatrix}1 & \sqrt{2}\rho\\ \sqrt{2}\rho & 2\end{bmatrix}$	$\begin{bmatrix}2 & 2\rho\\ 2\rho & 2\end{bmatrix}$	$\begin{bmatrix}1 & \rho\\ \rho & 1\end{bmatrix}$	$\begin{bmatrix}0.5 & 0.5\rho\\ 0.5\rho & 0.5\end{bmatrix}$

According to Equation (23), the matrix $\mathbf{D}$ is given by

$$\begin{bmatrix}1 & \rho\\ \rho & 1\end{bmatrix},$$

where ρ is the correlation coefficient between two quality characteristics.

Due to the fact that a 99.73% process region $E_{\chi^2_{2,\,0.9973},\boldsymbol{\Sigma},\mathbf{T}} = \{\mathbf{X} \in \mathbf{R}^2 | (\mathbf{X} - \mathbf{T})'\boldsymbol{\Sigma}^{-1}(\mathbf{X} - \mathbf{T}) \quad = \chi^2_{2,\,0.9973}\}$ and a 99.73% revised engineering tolerance region $E_{\chi^2_{2,\,0.9973},\mathbf{D},\mathbf{T}} = \{\mathbf{X} \in \mathbf{R}^2 | (\mathbf{X} - \mathbf{T})'\mathbf{D}^{-1}(\mathbf{X} - \mathbf{T}) = \chi^2_{2,\,0.9973}\}$ are equivalent, the values of MC_{ia} and MC_{ip} indices for process I should be nearly equal to 0 and 1 when the process mean is equal to the target. Moreover, process II represents the

variation of one quality characteristic is greater than 1, process III represents the variations of two quality characteristics are greater than 1, process IV represents the process mean vector is deviated from the target vector and process V represents both the variations of two quality characteristics are less than 1 and the process mean vector is deviated from the target vector respectively. Notice that the Mahalanobis distances between target vector and process mean vector are equal to 2 for process IV and V. A simulation study has been conducted 5,000 times and the results are summarized in Table 2.

Table 2: The simulation results of our multivariate process incapability indices for different correlation coefficients ρ.

		Ⅰ		Ⅱ		Ⅲ		Ⅳ		Ⅴ	
ρ	n	MC_{ia}	MC_{ip}	MC_{ia}	MC_{ip}	MC_{ia}	MC_{ip}	MC_{ia}	MC_{ip}	MC_{ia}	MC_{ip}
0.1	**30**	**0.0535**	**1.0029**	**0.0788**	**1.9819**	**0.1084**	**4.0114**	**1.6179**	**1.0057**	**0.8117**	**0.2514**
	50	**0.0307**	**1.0047**	**0.0442**	**1.9943**	**0.0628**	**4.0038**	**1.5775**	**0.9957**	**0.7928**	**0.2498**
	100	**0.0152**	**1.0002**	**0.0217**	**2.0033**	**0.0313**	**4.0006**	**1.5503**	**1.0006**	**0.7754**	**0.2511**
0.5	**30**	**0.0539**	**1.0087**	**0.0736**	**2.0234**	**0.1054**	**4.0220**	**1.5956**	**1.0075**	**0.7972**	**0.2547**
	50	**0.0311**	**1.0110**	**0.0436**	**2.0274**	**0.0622**	**4.0225**	**1.5677**	**1.0062**	**0.7737**	**0.2545**
	100	**0.0158**	**1.0075**	**0.0213**	**2.0012**	**0.0305**	**4.0289**	**1.5426**	**1.0022**	**0.7697**	**0.2501**
0.9	**30**	**0.0547**	**1.0588**	**0.0794**	**2.1266**	**0.1103**	**4.2508**	**1.5722**	**1.0571**	**0.7919**	**0.2656**
	50	**0.0315**	**1.0321**	**0.0444**	**2.0724**	**0.0624**	**4.1164**	**1.5518**	**1.0242**	**0.7773**	**0.2563**
	100	**0.0153**	**1.0155**	**0.0227**	**2.0325**	**0.0308**	**4.0270**	**1.5421**	**1.0012**	**0.7670**	**0.2546**

In Table 2, all the values of our MC_{ia} index for processes Ⅰ, Ⅱ and Ⅲ are close to zero for various correlation coefficients and all the values of our MC_{ia} index for processes Ⅳ and Ⅴ are greater than zero for various correlation coefficients. In addition, all the values of our MC_{ip} index for processes Ⅰ and Ⅳ are close to 1 for various correlation coefficients and all the values of our MC_{ip} index for processes Ⅱ and Ⅲ are greater than 1 for various correlation coefficients. Moreover, all the values of our MC_{ia} index are greater than zero and all the values of our MC_{ip} index are less than 1 for process Ⅴ, which reflect the properties of process Ⅴ. Therefore, we can conclude that the process precision and accuracy can correctly be reflected by our proposed MC_{ia} and MC_{ip} indices.

The estimation of MC_{pp} index and its sampling distribution

Assume that the key characteristics of a multivariate manufacturing process are normally distributed. Let $\mathbf{X}_1,\cdots,\mathbf{X}_n$ be a random sample of *n* measurements with p quality characteristics from a multivariate normal distribution with mean vector $\boldsymbol{\mu}$ and covariance matrix $\boldsymbol{\Sigma}$. In order to estimate the MC_{pp} index, the natural estimator of MC_{pp} index is defined as

$$\widehat{MC}_{pp} = \widehat{MC}_{ia} + \widehat{MC}_{ip} = (\bar{\mathbf{X}} - \mathbf{T})'\hat{\mathbf{C}}^{-1}(\bar{\mathbf{X}} - \mathbf{T}) + \frac{|\mathbf{S}|}{|\mathbf{D}|},$$

where $\bar{\mathbf{X}}$ is the sample mean vector, $\mathbf{S}$ is the sample covariance matrix and the diagonal and off-diagonal entries of matrix $\hat{\mathbf{C}}$ are

$$1_{\{\bar{X}_i \le T_i\}}c_{il}^2 + 1_{\{\bar{X}_i > T_i\}}c_{iu}^2$$

and

$$\rho_{ij}(1_{\{\bar{X}_i \le T_i\}}1_{\{\bar{X}_j \le T_j\}}c_{il}c_{jl} + 1_{\{\bar{X}_i \le T_i\}}1_{\{\bar{X}_j > T_j\}}c_{il}c_{ju} + 1_{\{\bar{X}_i > T_i\}}1_{\{\bar{X}_j \le T_j\}}c_{iu}c_{jl} + 1_{\{\bar{X}_i > T_i\}}1_{\{\bar{X}_j > T_j\}}c_{iu}c_{ju})$$

Since the $\widehat{MC}_{ia}$ index for asymmetric tolerances is a quadratic form and its sampling distribution is very complicated for asymmetric tolerances, we consider the MC_{ia} index for symmetric tolerances and its estimator can be written as

$$\widehat{MC}_{ia} = (\bar{\mathbf{X}} - \mathbf{T})'\mathbf{C}_s^{-1}(\bar{\mathbf{X}} - \mathbf{T}),$$

where the elements of matrix $\mathbf{C}_s$ are

$$\rho_{ij}D_iD_j,\ i,j = 1,\ldots,p, \qquad (24)$$

ρ_{ij} is the correlation coefficient between the *i*th and *j*th quality characteristics and $D_i = \min(D_{il}, D_{iu})/3$. Then, the sampling distribution of $\widehat{MC}_{ia}$ for symmetric tolerances can be written as

$$f(y) = \sum_{k=0}^{\infty}(-1)^k c_k \frac{y^{p/2+k+1}}{\Gamma(p/2+k)},$$

where

$$c_0 = \exp(-\frac{1}{2}\sum_{j=1}^{p} b_j^2) \prod_{j=1}^{p} (2\lambda_j)^{-\frac{1}{2}},$$

$$c_k = \frac{1}{k}\sum_{r=0}^{k-1} d_{k-r} c_r,\ k \geq 1,$$

$$d_k = \frac{1}{2}\sum_{j=1}^{p} (1 - k b_j^2)(2\lambda_j)^{-k},\ k \geq 1,$$

$$\mathbf{P}'\mathbf{\Sigma}^{\frac{1}{2}}\mathbf{C}_s^{-1}\mathbf{\Sigma}^{\frac{1}{2}}\mathbf{P}/n = diag(\lambda_1, \ldots, \lambda_p),\ \mathbf{P}'\mathbf{P} = \mathbf{I} \text{ and } \mathbf{b}' = (\mathbf{P}'(\mathbf{\Sigma}/n)^{-\frac{1}{2}}(\boldsymbol{\mu} - \mathbf{T}))'$$

(see Mathai and Provost, 1992). Furthermore, the *r*th moment of $\widehat{MC}_{ia}$ is derived below:

$$E(\widehat{MC}_{ia})^r = \left\{ \sum_{r_1=0}^{r-1} \binom{r-1}{r_1} g^{(r-1-r_1)} \sum_{r_2=0}^{r_1-1} \binom{r_1-1}{r_2} g^{(r_1-1-r_2)} \ldots \right\}, \text{ where}$$

$$g^{(k)} = 2^k k! \{ tr(\mathbf{C}_s^{-1}\mathbf{\Sigma}/n)^{k+1} + (k+1)(\boldsymbol{\mu} - \mathbf{T})'(\mathbf{C}_s^{-1}\mathbf{\Sigma}/n)^k \mathbf{C}_s^{-1}(\boldsymbol{\mu} - \mathbf{T}) \},\ k = 0, 1, 2, \ldots$$

Then, the expected value and variance of $\widehat{MC}_{ia}$ can be simplified to:

$$E(\widehat{MC}_{ia}) = MC_{ia} + tr(\mathbf{C}_s^{-1}\mathbf{\Sigma}/n)$$

$$Var(\widehat{MC}_{ia}) = 2tr(\mathbf{C}_s^{-1}\mathbf{\Sigma}/n)^2 + 4(\boldsymbol{\mu} - \mathbf{T})'\mathbf{C}_s^{-1}(\mathbf{\Sigma}/n)\mathbf{C}_s^{-1}(\boldsymbol{\mu} - \mathbf{T}))$$

Note that the estimator $\widehat{MC}_{ia}$ is asymptotically unbiased.
Since the sampling distribution of $\widehat{MC}_{ia}$ is too complicated to use, an approximate sampling distribution of $\widehat{MC}_{ia}$ is given by

$$\frac{\theta_3}{\theta_2}\chi_v^2 - \frac{\theta_2^2}{\theta_3} + E(\widehat{MC}_{ic}), \tag{25}$$

where $\theta_k = \sum_{j=1}^{p} \lambda_j^k (1 + k b_j^2)$, $k = 1, 2, 3$ and χ_n^2 is a chi-square distribution with $v = \theta_2^3/\theta_3^2$ degrees of freedom (see Mathai and Provost, 1992). Based the approximate sampling distribution of $\widehat{MC}_{ia}$ in Equation (25), we further prove that an approximate 100(1-α)% confidence interval for the MC_{ia} index is

$$\left[\widehat{MC}_{ia} - L_{MC_{ia}},\ \widehat{MC}_{ia} + U_{MC_{ia}} \right], \tag{26}$$

where $L_{MC_{ia}} = w\chi^2_{v,1-\alpha/2} + u + b_{MC_{ia}}$, $U_{MC_{ia}} = -(w\chi^2_{v,\alpha/2} + u + b_{MC_{ia}})$, $w = \theta_3/\theta_2$, $u = -\theta_2^3/\theta_3$, $b_{MC_{ia}} = tr(\mathbf{C}_s^{-1}\mathbf{\Sigma}/n)$ and $\chi^2_{v,\alpha}$ is the 100αth percentile of a chi-square distribution with v degrees of freedom. Since θ_k and $\mathbf{\Sigma}$ are usually unknown and it can be estimated by $\hat{\theta}_k = \sum_{j=1}^{p} \hat{\lambda}_j^k (1 + k\hat{b}_j^2)$ and sample covariance matrix $\mathbf{S}$ respectively, an approximate 100(1-α)% confidence interval for the MC_{ia} index can be written as

$$\left[\widehat{MC}_{ia} - \hat{L}_{MC_{ia}},\ \widehat{MC}_{ia} + \hat{U}_{MC_{ia}}\right], \tag{27}$$

where $\hat{L}_{MC_{ia}} = \hat{w}\chi^2_{\hat{v},1-\alpha/2} + \hat{u} + \hat{b}_{MC_{ia}}$, $\hat{U}_{MC_{ia}} = -(\hat{w}\chi^2_{\hat{v},\alpha/2} + \hat{u} + \hat{b}_{MC_{ia}})$, $\hat{w} = \hat{\theta}_3/\hat{\theta}_2$, $\hat{u} = -\hat{\theta}_2^3/\hat{\theta}_3$, $\hat{b}_{MC_{ia}} = tr(C_s^{-1}\mathbf{S}/n)$ and $\hat{v} = \hat{\theta}_2^3/\hat{\theta}_3^2$.

In order to assess the performance of the approximate confidence interval in Equation (27), a simulation study has been conducted and random samples with various sample sizes are generated from the multivariate normal distribution $N(\boldsymbol{\mu}, \mathbf{\Sigma})$. The specification limits and the target values are assumed to be $(LSL_1, USL_1) = (10, 16)$, $(LSL_2, USL_2) = (10, 16)$ and $\mathbf{T} = (13, 13)$. For each combination, 1,000 random samples are generated and the corresponding approximate 95% confidence intervals are computed for each sample. The observed coverage probability (i.e. the fraction of 1,000 computed confidence intervals which contain the actual value of the index) is recorded accordingly. When the interval estimates perform adequately, the observed coverage probability should be close to 95%. The observed coverage probabilities of an approximate 95% confidence interval for MC_{ia} index are given in Figure 2. Thus, a 99% confidence interval for the coverage probability of 0.95 is $0.95 \pm Z_{0.005}\sqrt{0.95 \times 0.05/1000} = 0.95 \pm 0.0178$. Hence, one can be 99% confident that a “true 95% confidence limit” will have a proportion of coverage from 0.933 to 0.967. According to the results of Figure 2 we can find that the approximate confidence interval for our MC_{ia} index in Equation (27) does not perform well when both the sample size and the value of MC_{ia} index are small. We conclude that with lower value of MC_{ia} index, larger sample sizes are required to have the 95% coverage probability. To reach a steady state as shown in Figure 2, eighty (80) samples are needed when $MC_{ia} \geq 1.0$.

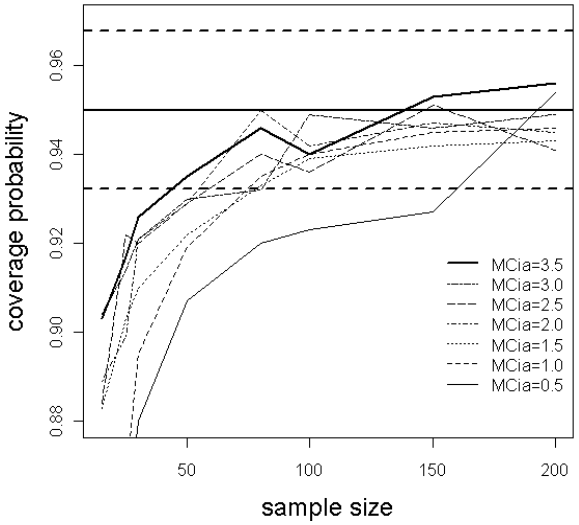

Figure 2: Observed coverage probabilities of the approximate 95% confidence interval.

Since $|\mathbf{S}|/|\mathbf{\Sigma}|$ is the distribution of $\prod_{i=1}^{p}\chi^2_{n-i}/(n-1)^p$ (see Maman, 2005), the estimator $\widehat{MC}_{ip}$ is distributed as $MC_{ip}\prod_{i=1}^{p}\chi^2_{n-i}/(n-1)^p$, where χ^2_{n-i} is an independent chi-square distribution with $(n-i)$ degrees of freedom. Thus, the *r*th moment of $\widehat{MC}_{ip}$ is derived as below:

$$\frac{1}{b_r}(MC_{ip})^r,$$

where

$$b_r = \left(\frac{n-1}{2}\right)^{\frac{rp}{2}} \prod_{i=1}^{p} \frac{\Gamma(\frac{n-i}{2})}{\Gamma(\frac{n-i}{2}+r)}$$

and the expected value and variance of $\widehat{MC}_{ip}$ can be simplified to:

$$E(\widehat{MC}_{ip}) = \frac{1}{b_1}MC_{ip}\ ,\ Var(\widehat{MC}_{ip}) = (\frac{1}{b_2} - \frac{1}{b_1^2})(MC_{ip})^2.$$

Note that the estimator $\widehat{MC}_{ip}$ is biased and $b_1\widehat{MC}_{ip}$ is an unbiased estimator. Based on the sampling distribution of $\widehat{MC}_{ip}$, we further prove that a 100(1-α)% confidence interval for MC_{ip} index is

$$\left[\frac{\widehat{MC}_{ip}}{w_{1-\alpha/2}}, \frac{\widehat{MC}_{ip}}{w_{\alpha/2}}\right], \tag{28}$$

where w_α is the 100αth percentile of the distribution of $\prod_{i=1}^{p}\chi^2_{n-i}/(n-1)^p$.

Numerical Examples

Example 1:

Sultan (1986) discussed an example in which the Brinell hardness (*H*) and tensile strength (*S*) are two quality characteristics for an industrial product. The engineering tolerances for *H* and *S* are given by (112.7, 241.3) and (32.7, 73.3) respectively and the target vector for *H* and *S* is (177, 53). After collecting 25 measurements listed in Table 3, a process capability study is conducted assuming the process is in control.

Table 3: The 25 data sets of Brinell hardness (H) and tensile strength (S) for an industrial product.

H	S	H	S	H	S
143	**34.2**	**141**	**47.3**	**178**	**50.9**
200	**57.0**	**175**	**57.3**	**196**	**57.9**
160	**47.5**	**187**	**58.5**	**160**	**45.5**
181	**53.4**	**187**	**58.2**	**183**	**53.9**
148	**47.8**	**186**	**57.0**	**179**	**51.2**
178	**51.5**	**172**	**49.4**	**194**	**57.5**
162	**45.9**	**182**	**57.2**	**181**	**55.6**
215	**59.1**	**177**	**50.6**		
161	**48.4**	**204**	**55.1**		

Based on the 25 measurements listed in Table 3, the sample mean vector $\overline{\mathbf{X}}' = [177.2, \quad 52.316]$ and the sample covariance matrix $\mathbf{S}$ are calculated, where

$$\mathbf{S} = \begin{bmatrix} 338 & 88.8925 \\ 88.8925 & 33.6247 \end{bmatrix}.$$

According to Equations (23) and (24), the matrices $\mathbf{D}$ and $\mathbf{C}_s$ can be obtained as below:

$$\mathbf{D} = \begin{bmatrix} 349.5213 & 92.0102 \\ 92.0102 & 34.8372 \end{bmatrix}$$

$$\mathbf{C}_s = \begin{bmatrix} 459.3878 & 120.9322 \\ 120.9322 & 45.7878 \end{bmatrix}$$

The actual relationship among the 99.73% process region, the 99.73% revised engineering tolerance region and engineering tolerance region are shown in Figure 3.

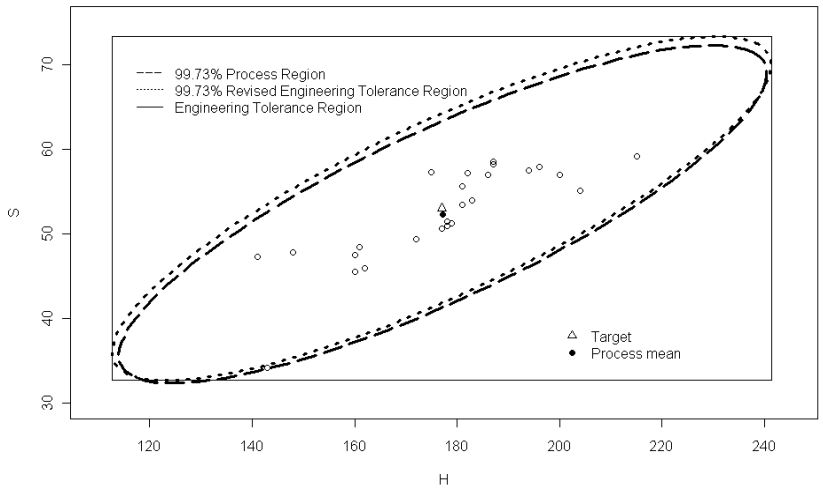

Figure 3: Relationship among 99.73% revised engineering tolerance region, 99.73% process region and engineering tolerance region.

Apparently, the process mean is close to the target and the "99.73% process region" is approximately equal to the "99.73% revised engineering tolerance region". Since the estimated conforming rate for this example is 99.91% under the assumption of multivariate normality for the underlying process distribution and our proposed indices are $\widehat{MC}_{ia} = 0.04$ and $\widehat{MC}_{ip} = 0.93$ respectively, the results show that the 99.73% process region is close to the 99.73% revised engineering tolerance region, and that the process mean is close to the target (see Figure 3). Thus, our proposed indices, $\widehat{MC}_{ia}$ and $\widehat{MC}_{ip}$, indicate that the multivariate process is capable and the true process performance is reflected.

Example 2:

In this example, a historical aircraft data sets collected by Pratt and Whitney Company (Niverthi and Dey, 2000) is used for illustration. The data set has measurements on ten (10) different aircraft features which are taken from a component hub of the engine. After performing the Shapiro-Wilk test, one can find out that three (3) of ten (10) different aircraft features in this data set are multivariate normally distributed with the mean vector $\overline{\mathbf{X}}' = [22.0492, 1.8544, 3.04675]$ and the covariance matrix

$$\mathbf{S} = \begin{bmatrix} 9.2016\times10^{-8} & 1.9592\times10^{-8} & -6.9796\times10^{-8} \\ 1.9592\times10^{-8} & 1.1755\times10^{-7} & -3.5510\times10^{-8} \\ -6.9796\times10^{-8} & -3.5510\times10^{-8} & 3.7879\times10^{-6} \end{bmatrix}.$$

Since our proposed index is based on the normality assumption for the underlying distribution, we only consider three aircraft features which follow multivariate normal

distribution. Given the engineering tolerances of the three aircraft features (22.047, 22.051), (1.852, 1.856) and (3.038, 3.052) and the target vector (22.049, 1.854, 3.045), the matrices $\mathbf{D}$ and $\mathbf{C}_s$ can be obtained as below according to Equations (16) and (23).

$$\mathbf{D} = \begin{bmatrix} 2.8256\times10^{-7} & 5.3228\times10^{-8} & -1.1692\times10^{-7} \\ 5.3228\times10^{-8} & 2.8256\times10^{-7} & -5.2629\times10^{-8} \\ -1.1692\times10^{-7} & -5.2629\times10^{-8} & 3.4614\times10^{-6} \end{bmatrix}$$

$$\mathbf{C}_s = \begin{bmatrix} 4.4444\times10^{-7} & 8.3723\times10^{-8} & -1.8390\times10^{-7} \\ 8.3723\times10^{-8} & 4.4444\times10^{-7} & -8.2781\times10^{-8} \\ -1.8390\times10^{-7} & -8.2781\times10^{-8} & 5.4444\times10^{-6} \end{bmatrix}$$

The incapability indices and their associated interval estimates are summarized in Table 4. The two components of a multivariate process incapability index, $\widehat{MC}_{ia} = 1.03$ and $\widehat{MC}_{ip} = 0.15$, indicate that this multivariate manufacturing process exhibits a fairly high risk mainly due to the process inaccuracy. After performing the baseline analysis, quality practitioners can focus their improvement efforts on reducing the risk caused by process inaccuracy. Therefore, the information of process inaccuracy and process variation revealed by $\widehat{MC}_{ia}$ and $\widehat{MC}_{ip}$ indices can be served as a useful guideline for pointing out the directions for future quality improvements.

Table 4: The process incapability indices and their associated interval estimates.

	Process Incapability Indices		
	$\widehat{MC}_{ia}$	$\widehat{MC}_{ip}$	$\widehat{MC}_{pp}$
Indices	**1.03**	**0.15**	**1.18**
Interval Estimates	**[0.88, 2.16]**	**[0.09, 0.34]**	**[0.97, 2.504]**

Note: Values within bracket represent the 95% confidence intervals for respective indices.

CONCLUSIONS AND FUTURE RESEARCH

In many industries, the quality of the process is often determined by several quality characteristics, some of which are correlated. To assess the risk of correlated multiple quality characteristics, new multivariate process incapability indices are proposed by considering that the key quality characteristics are independent first and then relieving the independent

assumption to a dependent one. Based on the concepts of Pignatiello's (1993) multiple response loss function and slant ellipsoid-shaped regions, the two components of a multivariate process incapability indices, MC_{ia} (the inaccuracy index) and MC_{ip} (the imprecision index), are developed respectively. Moreover, the statistical properties of the estimators of MC_{ia} and MC_{ip} indices, such as their *r*th moment, expected value and variance are derived. The confidence intervals for MC_{ia} and MC_{ip} indices are also constructed by taking sampling error into account. Finally, in two numerical examples, we have demonstrated that the correlated risk for a multivariate manufacturing process as well as its expected losses can be evaluated in a more precise way by using the new multivariate process incapability indices.

In this paper, the development of multivariate process incapability indices is based on the assumption of normality. The future researchers may consider developing non-normal process incapability indices for both univariate and multivariate cases. Another research area is to further explore the relationship between the multivariate process incapability indices and their associated non-conforming rates. In addition to two-sided specification limit, one-sided specification limit are often encountered in the environmental research and service industries. Thus, the development of a new process incapability index for one-sided specification limit is the third potential research area needs to be further studied.

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EFFICIENT INTERVAL GOAL PROGRAMMING FOR ARBITRARY PENALTY FUNCTION

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ABSTRACT

Penalty function is a key factor in interval goal programming (IGP), especially for decision-maker weighing resources vis-à-vis goals. Many approaches have been proposed for treating several types of penalty function in the past several decades. The recent approach proposed by Chang (2009) considers the S-shaped penalty function. Although there are many approaches in literatures, all are complicated and inefficient. This paper proposes a novel and concise uniform model to treat any arbitrary penalty function in IGP. The efficiency and usefulness of the proposed model are demonstrat by several numeric examples.

Keywords: interval goal programming, penalty function

INTRODUCTION

The goal programming (GP) model is a well-known aggregating procedure for solving multi-objective decision problems. This takes into account many objectives simultaneously, which can be conflicting. GP was firstly proposed by Charnes and Cooper (1961) and has been applied to many real-world problems in areas like management, marketing, economics, engineering, transformation, finance, government, and internal context (Schniederjans, 1995; Lai and Hwang, 1994). It is an important technique in considering several objectives for finding an acceptable solution. It can be said that GP is the most widely used technique for solving multi-criteria and multi-objective decision-making problems. It can be formulated in the following traditional form:

$$\begin{aligned} \text{Min} \quad & \sum_{i=1}^{m} (w_i^- n_i + w_i^+ p_i) \\ \text{s.t.} \quad & f_i(\mathbf{x}) + n_i - p_i = g_i, \ i = 1,...,m, \\ & \mathbf{x} \in \mathbf{F}; \ n_i, p_i \geq 0 \ \forall i. \end{aligned}$$

where $\mathbf{x}$ is a vector of decision variables, $\mathbf{F}$ is a feasible set of constraints, $f_i(\mathbf{x})$ and g_i are the goal function and its aspiration level, n_i and p_i are negative and position unwanted deviations from its target value, respectively. Any unwanted deviation with respect to its target is penalized according to the marginal constants w_i^- and w_i^+.

Many approaches (Jones and Tamiz, 1995; Vitoriano and Romero, 1999; Romero, 2004; Chang, 2006; Chang, 2009) have been proposed for treating different shapes of penalty function in the past few decades. Different penalty functions require different approaches to solve the IGP problem. Although there are many approaches in literature, there is a lack of a concise uniform model to treat any arbitrary penalty function in IGP. This paper proposes a novel model to solve this practical problem and has the following features:

(*i*) Regardless of the complexity of the penalty function, this model will easily treat any type of penalty function in a uniform way.

(*ii*) This uniform model is more concise and efficient than current ones.

CURRENT RELATED IGP MODEL

The idea of IGP proposed by Charnes and Collomb (1972) was first developed by Jones and Tamiz (1995). Increasing penalty and reverse penalty models were introduced in their article. For example, take an IGP problem with m goals. Suppose there are $k1+k2$ attribute values (the points of position on to the related target value) in penalty function of the *i*th goal. The attribute values are $a_{i,k1},...,a_{i,1},b_{i,1},...,b_{i,k2}$ where $a_{i,k1}<...<a_{i,1}<b_{i,1}<...<b_{i,k2}$. Then, the marginal penalty rates for each segment between adjacent attribute values are $\alpha_{i,k1-1},...,\alpha_{i,1},0,\beta_{i,1},...,\beta_{i,k2-1}$. This U-shaped penalty function (Fig. 1) can be expressed by Jones and Tamiz (1995) as follows:

Jones and Tamiz's model (1995):

$$\text{Min} \quad \sum_{i=1}^{m}\left[\alpha_{i,1}n_{i,1}+\sum_{j=2}^{k1-1}(\alpha_{i,j}-\alpha_{i,j-1})n_{i,j}+\beta_{i,1}\rho_{i,1}+\sum_{j=2}^{k2-1}(\beta_{i,j}-\beta_{i,j-1})\rho_{i,j}\right]$$

s.t.
$$f_i(\mathbf{x})+n_{i,j}-p_{i,j}=a_{i,j},\ j=1,...,k1-1,\ i=1,...,m, \tag{1}$$
$$f_i(\mathbf{x})+\eta_{i,j}-\rho_{i,j}=b_{i,j},\ j=1,...,k2-1,\ i=1,...,m, \tag{2}$$
$$n_{i,j}\le Mu_{i,j},\ p_{i,j}\le M(1-u_{i,j}),\ j=2,...,k1-1, \tag{3}$$
$$\eta_{i,j}\le Mv_{i,j},\rho_{i,j}\le M(1-v_{i,j}),\ j=2,...,k2-1, \tag{4}$$
$$\mathbf{x}\in\mathbf{F};\ n_{i,j},p_{i,j},\eta_{i,j},\rho_{i,j}\ge 0\ \forall i,j,$$

where $u_{i,j}$ and $v_{i,j}$ are binary variables, M is a big enough constant, and $n_{i,j}$ and $\rho_{i,j}$ present deviation variables for the left U-shaped penalty function and the right U-shaped penalty function, respectively .

For this U-shaped penalty function, two cases can be used in the Jones and Tamiz's model. One is increasing penalty case ($\alpha_{i,j+1}>\alpha_{i,j},\beta_{i,j+1}>\beta_{i,j}\ \forall i,j$), which only require Constraints (1) and (2). The other one is reverse penalty case ($\alpha_{i,j+1}<\alpha_{i,j},\beta_{i,j+1}<\beta_{i,j}\ \forall i,j$), which uses Big-M Constraints (3) and (4) to avoid both $n_{i,j}$ and $p_{i,j}$ ($\eta_{i,j}$ and $\rho_{i,j}$) becoming zero simultaneously, since the coefficients of $n_{i,j}$ ($\rho_{i,j}$) in achievement function are negative.

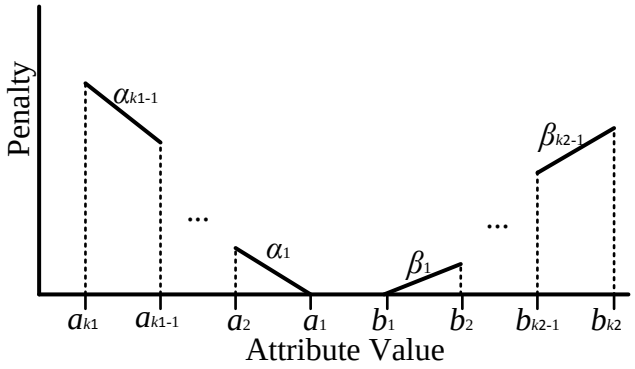

Figure 1: A U-shaped penalty function.

Recently, Chang (2006) proposed a new model of increasing penalty function for improving efficiency. The two aforementioned models (Jones and Tamiz, 1995; Chang, 2006) solve the penalty function regardless if marginal penalty rates for sequence segments are increasing or decreasing. However, these cannot solve the complex penalty function in an IGP. Yang et al. (1991) proposed a model for solving fuzzy programming problems with S-shaped membership function. Li and Yu (1999) showed that Yang et al.'s (1991) model is correct only for a specific type membership function and proposed their own model for other types of membership functions. Lin and Chen (2002) generalized the model of Yang et al. (1991) and indicated that the model of Li and Yu (1999) is inapplicable to a fuzzy programming problem involving more than one membership function. Recently, Chang and Lin (2009) proposed a complex formulation to solve the simplest S-shaped penalty function in an IGP problem.

However, when the models of Jones and Tamiz (1995) and Chang and Lin (2009) meet the reverse penalty case, they will become inefficient and complicated because of the Big-M constraints. Although there are many approaches in literature, all have been complicated and inefficient up to now. This paper proposes an efficient and concise uniform model to treat any arbitrary penalty function in IGP.

PROPOSED IGP MODEL FOR ARBITRARY PENALTY FUNCTION

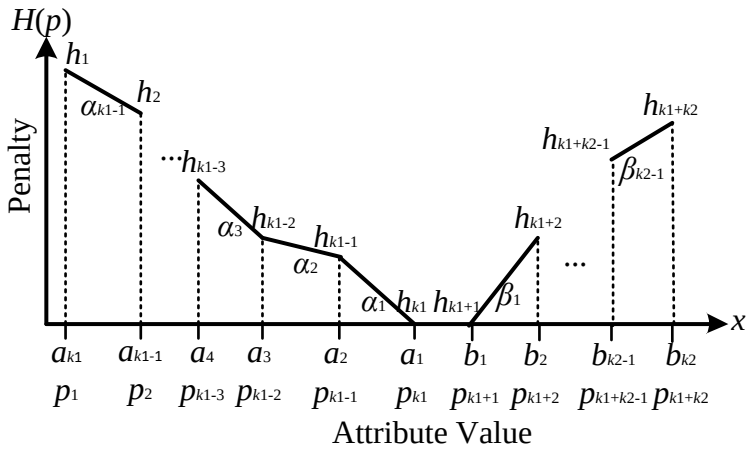

Figure 2: An arbitrary penalty function.

An arbitrary penalty function in IGP is a difficult problem (Fig. 2) since DMs can choice their preferred the marginal penalty rates for each segment between adjacent attribute values. As such, the slopes of each segment can be any arbitrary value, either positive or negative. For convenient modeling, another symbol is used to denote the original attributed values. Hence, $p_1 = a_{k1}$, …, $p_{k1} = a_1$, $p_{k1+1} = b_1$, …, $p_k = b_{k2}$ ($k = k1 + k2$). The arbitrary penalty function can be expressed by Proposition 1.

Proposition 1 *The penalty function* $H(p)$ (*Fig. 2*)*,* h_j *is the penalty value related to the attribute values* p_j *where* $j = 1,...,k$ $(H(p_j) = h_j)$ *.* k *positive continuous variables* $(\lambda_1,...,\lambda_k)$ *and* $k-1$ *binary variables* $(u_1,...,u_{k-1})$ *are introduced in this model.* $H(p)$ *can be expressed by the following linear equations and inequalities:*

$$p = \sum_{j=1}^{k} \lambda_j p_j , \tag{5}$$

$$H(p) = \sum_{j=1}^{k} \lambda_j h_j , \tag{6}$$

$$\sum_{j=1}^{k} \lambda_j = 1, \tag{7}$$

$$\sum_{j=1}^{k-1} u_j = 1, \tag{8}$$

$$\lambda_1 \le u_1 , \ \lambda_j \le u_{j-1} + u_j , j = 2,...,k-1 , \ \lambda_k \le u_{k-1} . \tag{9}$$

Proof It is trivial. □

In Proposition 1, the value of penalty in (6) will be zero when $u_{k1} = 1$ because the goal value between a_1 and b_1 meets the aspiration level that DMs choose. Afterwards, the penalty will be continuously increasing depending on the marginal penalty rates when the goal value is far away from the aspiration level. The model in Proposition 1 has an improvement over current models since there are no Big-M constraints. However, Constraint (9) requires $k-1$ binary variables and k constraints to construct the model. It still seems inefficient for solving the arbitrary penalty function in IGP. Vielma and Nemhauser (2010) proposed a technology that constructs Constraint with a logarithmic number of binary variables and constraints. Therefore, Vielma and Nemhauser (2010)'s technology is used to reduce the required binary variables and constraints and conduct the concise uniform model for treating any arbitrary penalty function. The proposed model is described in Proposition 2.

Proposition 2 *The penalty function $H(p)$ in Proposition1 can be expressed by the following linear equations and inequalities:*

$$\text{Min} \quad \sum_{i=1}^{m}\sum_{j=1}^{k}\lambda_{i,j}h_{i,j}$$

$$\text{s.t.} \quad f_i(\mathbf{x}) = \sum_{j=1}^{k}\lambda_{i,j}p_{i,j},\ i=1,...,m,$$

$$\sum_{j=1}^{k}\lambda_{i,j}=1,\ i=1,...,m, \tag{10}$$

$$\sum_{j\in J_l^+}\lambda_{i,j}\le v_{i,l},\ \sum_{j\in J_l^-}\lambda_{i,j}\le(1-v_{i,l}),\ l=1,...,r,\ i=1,...,m, \tag{11}$$

$$\mathbf{x}\in\mathbf{F};\ \lambda_{i,j}\ge 0\ \forall i,j;\ v_{i,l}\in\{0,1\}\ \forall i,l, \tag{12}$$

where

(i) $p_{i,j}$ and $h_{i,j}$ are the attribute values and related penalty value for goal i

$(p_{i,1}<...<p_{i,k})$,

(ii) J_l^+ and J_l^- are same in Proposition 2,

Proof It is similar to Proposition 1. □

NUMERICAL EXAMPLES

To demonstrate the usefulness and efficiency of the proposed model, three examples are presented here and are solved by CPLEX 11 (ILOG 2008) on a PC with 3.16 GHz Core™2 Duo CPU and 4GB RAM.

Example 1 The example is modified from the IGP problem of Vitoriano and Romero (1999). The problem is expressed as follows and the three goal penalty scale data are listed in Table 1.

$$\text{Goals:} \quad (f_1(\mathbf{x}))\ 3x_1+2.5x_2+2.5x_3=100$$
$$(f_2(\mathbf{x}))\ 4x_1+3x_2+3.5x_3=100$$
$$(f_3(\mathbf{x}))\ 3.8x_1+5x_2+3.5x_3=100$$

$$\text{s.t.} \quad x_2+x_3\ge 10, \tag{13}$$

$$x_1\ge 0,\ x_2\ge 4,\ x_3\ge 0. \tag{14}$$

Only two models (Chang and Lin, 2009; proposed model) can solve this IGP because those penalty functions are U-shaped, S-shaped, and arbitrary shaped respectively.

By referring to Chang and Lin (2009), this example can be formulated as a complicated and inefficient model. For the arbitrary penalty function (Goal 3), this model uses much binary

variables and Big-M constraints to restrict the domain of $n_{i,j}$ and $\rho_{i,j}$. Each of non-linear term ($u_{2,3}f_2(\mathbf{x})$, $v_{2,3}f_2(\mathbf{x})$, $u_{3,2}f_3(\mathbf{x})$, $v_{3,2}f_3(\mathbf{x})$, $u_{3,3}f_3(\mathbf{x})$, $v_{3,3}f_3(\mathbf{x})$) also require an additional binary variable and four Big-M constraints for linearization. The efficiency of this model will be hampered by the Big-M constraints. Compared to Chang and Lin's (2009) model, the proposed model is concise and efficient for treating any arbitrary penalty function in IGP. The respective computational times, iterations, binary variables, additional constraints, and solution are listed in Table 2.

Table 1: Penalty scale for the three goals.

Goals	Description	Interval (Unit %)	Marginal penalty
1	U-shaped increasing penalty function	10~80	3
		80~90	2
		90~100	1
		100~110	0
		110~120	1
		120~130	2
		130~200	3
2	S-shaped penalty function	10~80	0.9
		80~90	2
		90~100	1
		100~110	0
		110~120	1
		120~130	2
		130~200	0.9
3	Arbitrary penalty function	10~80	2
		80~90	1
		90~100	2
		100~110	0
		110~120	2
		120~130	1
		130~200	2

Table 2: The Computation Results for Example 1.

Item	Chang and Lin's model	Proposed model
CPU Time(sec)	0.11	0
No. of iterations	47	16
No. of 0-1 variables	12	9
No. of constraints	60	21
Solution (x_1, x_2, x_3)	(18.33, 4, 6)	
Goal (1,2,3)	(80, 106.33, 110.67)	

CONCLUSION

This paper proposes an efficient and concise model to treat any arbitrary penalty function in IGP. Regardless of the complexity of the penalty function, this model can efficiently solve any arbitrary penalty function in a uniform way, and with binary variables and constraints that only require logarithmic numbers of original ones. Numerical examples show that this novel model for treating arbitrary penalty function in IGP has favorably tight properties, while computational results demonstrate that it significantly outperforms current models, especially when the scale of a problem is large.

ACKNOWLEDGMENTS

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MIXED AND INTELLIGENT SIMULATION MODELS FOR LOGISTICS EMERGENCY SITUATIONS

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ABSTRACT

Seaports are important nodes in modern supply chains and have a large impact on national wellbeing. A disruption in these links can have a high impact on the whole society. Preparation is important if crises want to be handled efficiently. This paper analyzes how logistical emergency situations can be modeled with hybrid simulation modelling. Simulations are one possible way to analyze, how complex systems develop through time. The focus is on maritime transportation in the Gulf of Finland. Queuing models from Discrete-Event Simulation was combines with Agent-Based Modelling to have more realistic models. This paper provides an overview, how it is possible to model individual ships using available data and creating a network of connections between potential seaborne routes. The simulation model estimates, how long queues will develop to backup seaports, if some seaports cannot be used due to disruptions. Also, the importance of coordination is highlighted in this paper. Practical action points, like importance of weekend work and amount of working shifts at the seaports in the time of emergency are highlighted by the simulation results.

Keywords: Agent-Based Modeling, Simulation, Logistics, Containerization, Risk management

INTRODUCTION

During the spring of 2010 there was a huge oil spill in the Gulf of Mexico. Nearly 5 million barrels of oil spilled out (Achenbach and Fahrenthold 2010) and it will have a long-term impact for both the environment and the economy. Repeating similar negative outcome to Exxon Valdez oil tanker accident in Alaska during 1989 (, where 0.35 mill. barrels were spilled out to fragile Northern nature; BBC, 2011a), as well as Erika and Prestige oil spills in the France/Spanish coast-line during years 1999 and 2002 (BBC, 2011b; Rainsford, 2010). Spillages also create pressures for logistical systems as a spillage can force a seaport to be closed for the duration of the cleaning operations. The Gulf of Finland is especially a sensitive area as the passage is narrow and there is a heavy traffic flow of oil ships from the port of Primorsk, but also from Estonian seaport, Muuga (Tallinn) (Kämärä 2010).

Seaports act as important nodes in global supply chains (Panayides and Song 2008). Congestion is one important category in port competitiveness (Yeo et al. 2008; Tongzon and

Heng, 2005) and they have a large impact on national wellbeing as well. A disruption in port operations might have a big impact as many nations are heavily dependent on seaborne transportation. On global scale over 40 % of all trade is conducted using seaports (World Trade Organization 2009) and in some countries the share is even larger. In Finland roughly 80 – 90 % of all trade in tons is through seaports (Finnish Customs 2011),

Preparation is critical in crisis situations (Long 1997). Preparation phase is the strategic planning for the operations during the actual crisis. This paper will concentrate on developing a method to analyze logistical system in these types of situations. However, it is not an easy task. If no other method can be used to analyze a complex system, simulation can be used as a final method (Law 2006). Agent-Based Modelling has started to gather more interest in the academia, but models in Operational Research are still scarce (Siebers et al. 2010). However, it can provide improved understanding on systems, which were earlier too complex to be modelled by using other, more traditional, approaches (Macal and North, 2006).

The research question in this paper is: "*How can logistics emergency situations be simulated with Agent-Based Modelling?*" In this study we use a hybrid simulation model to analyze how logistical flows will function in a crisis situation. A hybrid approach is used as Discrete-Event Simulation provides many good ways to model queuing systems. However, it lacks the versatility of Agent-Based Modelling. As such, hybridization was our chosen approach.

This paper is structure as follows. In the second section information about risk management is presented. The third section provides an overview about simulations. The section presents general information from simulation, as well as the used simulation approaches. The fourth section concentrates on the research background. The research project behind this study is presented. The fifth section gives an overview about the simulation model, while the sixth section analyzes the model's results. The final section concludes this study and provides further avenues for research.

SUPPLY CHAIN RISK MANAGEMENT

Most research on intermodal supply chains concentrated on efficiency and capacity estimation prior of 9/11. This research included optimal scheduling of container terminal construction (Fung 1998), impact of insufficient capacity on commodity prices (Terahara 1999), and fine tuning operational strategies in intermodal train operations (Newmann 1998). Since 9/11 risk management has started to gather more interest. Vandiver (2006) identified critical infrastructure in the U.S. Computers, telecommunication equipment, and pharmaceutical preparations were seen to be most critical cargo as they have a high impact to other sectors and are difficult to substitute. Direnzo (2007) estimated maritime risk related to different regions. Trade and passenger flows in the US were used to estimate the high risk areas. Handley-Schachler and Navare (2010) highlight the importance of identifying risk allocation and sustainability in port systems, as they are usually partially owned by public sector and operated by the private sector. According to de Langen (2004) the port governance structure also has a great impact on seaport performance.

A related issue is the handling of different types of goods. Some dangerous goods (such as flammable liquids, dangerous gases, etc.) require special attention. A risk management framework for dangerous goods transportation has been proposed by Batarlienė (2008). However, recently 100% inspection for containers has been suggested by U.S. officials and it might have a big impact on port operations (Bakshi et al. 2011). Figure 1 shows the most important variables regarding risk management within nodes in supply chains. The whole supply chain consists then from many nodes which each with their own risk management as well as the actual transportation between the nodes. This requires coordination between the partners. The coordination consists of contracts, information technology, information sharing, and joint-decision making (Arshinder et al. 2008). Figure 2 represents the risk management in a supply chain.

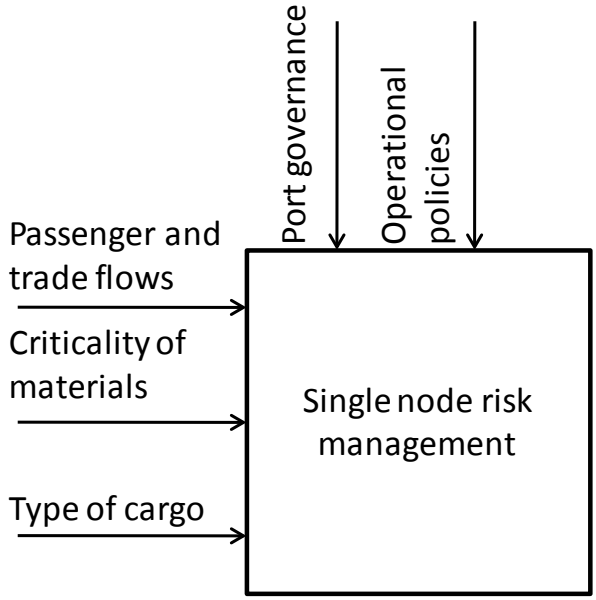

Figure 1: Variables impacting risk management in transportation nodes.

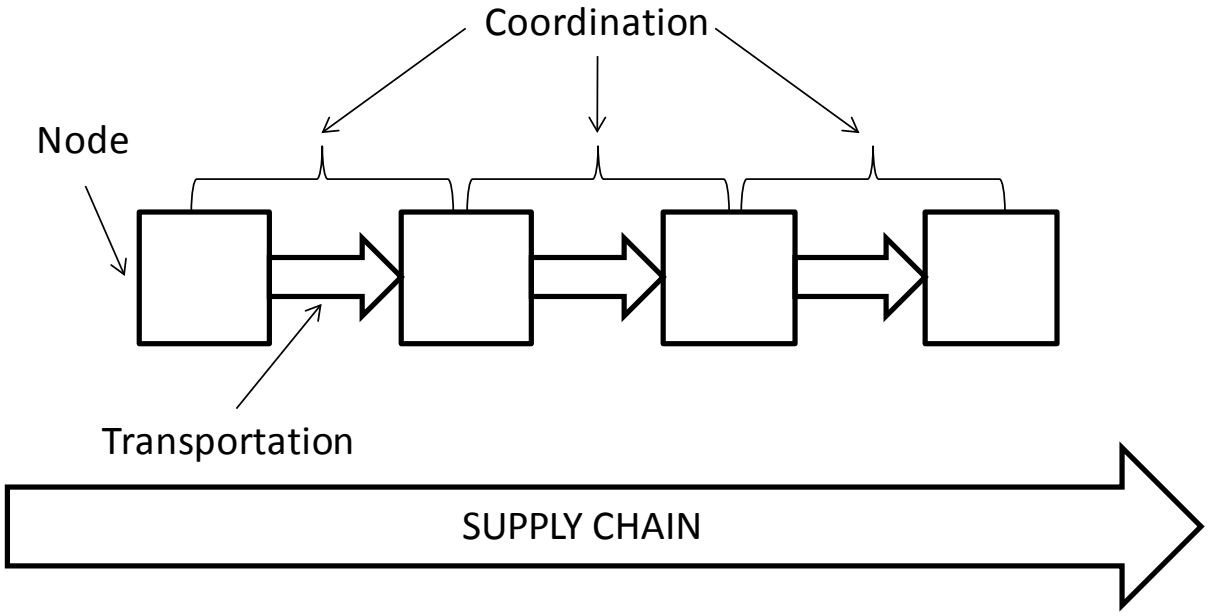

Figure 2: Supply chain risk management.

Mansouri et al. (2010) have proposed a framework to create resilient port infrastructure systems. In the first phase the vulnerabilities are assessed. During the second phase resilience strategies are developed. In the final phase investment strategies are valued. The resilience of the whole system will not only depend on the resilience of individual nodes but strong interdependencies between nodes exist. For instance, if there is a stoppage in one part of the chain, it might ripple through the whole chain. If one train is missed, it is possible to miss a connecting ship and the whole delivery is delayed.

SIMULATION MODELLING

Simulation as a Part of the Operations Research Toolkit

Simulation is one possible tool in operations research (Hillier and Lieberman 2005). The purpose of operations research is to improve organizational performance by finding best possible (or good) solutions to problems. Robinson (2004, p.4) has defined simulations as "Experimentation with a simplified imitation (on a computer) of an operations system as it progresses through time, for the purpose of better understanding and/or improving that system". Simulation does not guarantee improvement, but it can be combined with heuristics and/or optimization (Ivanov 2009).

According to Robinson (2004), three key issues separate simulation from other modelling approaches. Many traditional modelling approaches do not contain stochastic elements, which might have a big impact on the final results. Secondly, simulation does not contain restrictive assumptions, which might be difficult to take into account in other modelling approaches. Thirdly, simulation models have an animated display, which allows more transparency than a large set of equation or large spreadsheet models.

Many different simulation approaches exist. According to Jahangirian et al. (2010), the most widely used approaches in manufacturing and business are discrete-event simulation (DES), system dynamics, hybrid models, and agent-based modeling (ABM). The approaches used in this paper (ABM and DES) are introduced in the following sections.

Agent-Based Modelling

Agent-Based Modelling is a relatively new approach in simulation modeling. The original concept trace back to von Neumann machines but it started to gather more interest in the 1990s as computational power started to increase rapidly (Macal and North, 2005). One of the first applications was Schelling's segregation model (Schelling, 1969). The model consisted of a grid of household. Each household had preferences regarding their neighborhood. If too many neighbors were of different condition (this could be income level, education, race, etc.), the household decided to move to a new location. Eventually the system reaches a equilibrium where different types of households live in segregated environments.

According to Macal and North (2006) there are four primary reasons for the increased interest in Agent-Based Modelling. Firstly, observed systems are becoming more complex in

terms of interdependence. Secondly, some systems have been too complex to model using other approaches. Thirdly, even more data exists in a higher level of granuility. Finally, the rapid increase in computational power has made the simulations possible. According to Davidsson et al. (2005) and Hilletofth et al. (2010), most of the work in Agent-Based Modelling is still on a conceptual level and only few empirical models exist.

Many different classifications for agents have been presented but there are no agreement regarding the subject (Schieritz and Milling 2003). Few basic principles still apply to the actual modeling approach. The main area of interest is the agents and their decisions. The agents exist in an environment and gather local information for simulation system. The agents will then interact with other agents and the system's behavior emerges from the interaction. (Wooldridge and Jennings 1995)

Discrete-Event Simulation

The main focus in DES is discrete-events, which occur during the simulation run. The events are located in a calendar. As soon as the simulations time reaches an event, it will be executed. Each event will be executed one at a time. White and Ingalls (2009) provide an overview about the most important aspects in DES. They are presented in Table 1.

Table 1: Concepts in discrete-event simulation (White and Ingalls 2009).

Concept	Description
Inputs	Actions of environment on the system
Outputs	Measured quantities
State	Internal condition of the system
Entities	Dynamic entities which flow through the system's structure
Attributes	Unique characteristics of an entity
Activities	Processes and logic in the model
Events	Conditions occurring during the simulation, which causes a change in the system's state
Resources	Anything which has a constrained capacity
Global variables	Variable containing information about the system
Random number generator	Generates randomized values to be used during the simulation
Statistics collector	Collects statistics on conditions

Servers and queues are heavily used within DES. Entities enter the model through various sources and wait in queues to be served by different servers. There is a delay when the server handles the entity and the entity then moves to a new queue. Eventually the entities exist through sinks. (Banks et al. 2005)

RESEARCH BACKGROUND

This research was conducted during an EU funded (Interreg IV A programme) STOCA project (Study of Cargo Flows in the Gulf of Finland in Emergency Situations). The project consisted of many work packages conducted by different organizations. One package concentrated on creating simulation models for emergency situations. This paper presents one of these

models. Prior to the model construction interviews were conducted. The interviewees consisted from various logistical operators in the Gulf of Finland area. The models were constructed based on the interviews. More information from the interviews can be found in Karttunen et al. (2010).

Simulation was chosen as the research methodology as the problem domain is extremely complex and it might be difficult to include all of the important dimensions in analytical model. In these cases simulation is a justified approach (Law 2006). Agent-Based Modelling has started to gather more interest in the academia but models in Operational Research are still scarce (Siebers et al. 2010). However, it can provide improved understanding on systems, which were earlier too complex to be modelled by using other, more traditional, approaches (Macal and North, 2006). During the project System Dynamics models were as well constructed, but they will not be presented in this paper.

Gulf of Finland is located between Finland, Estonia, and Russia in the Baltic Sea Region. The largest seaports of the region are located in Russia. The largest one, Primorsk, handles 75+ million tons of oil products each year. The second largest, Port of Saint Petersburg, handles over 50 million tons of various cargo. Other major seaports in the area include Vysotsk (Russia), Ust-Luga (Russia, in the medium-term planned to reach 100+ mill. tons handling volume), Sköldvik (Finland), Helsinki (Finland), Kotka and Hamina (Finland), and Tallinn (Estonia). The map of the area is presented in Figure 3. (Kämärä 2010)

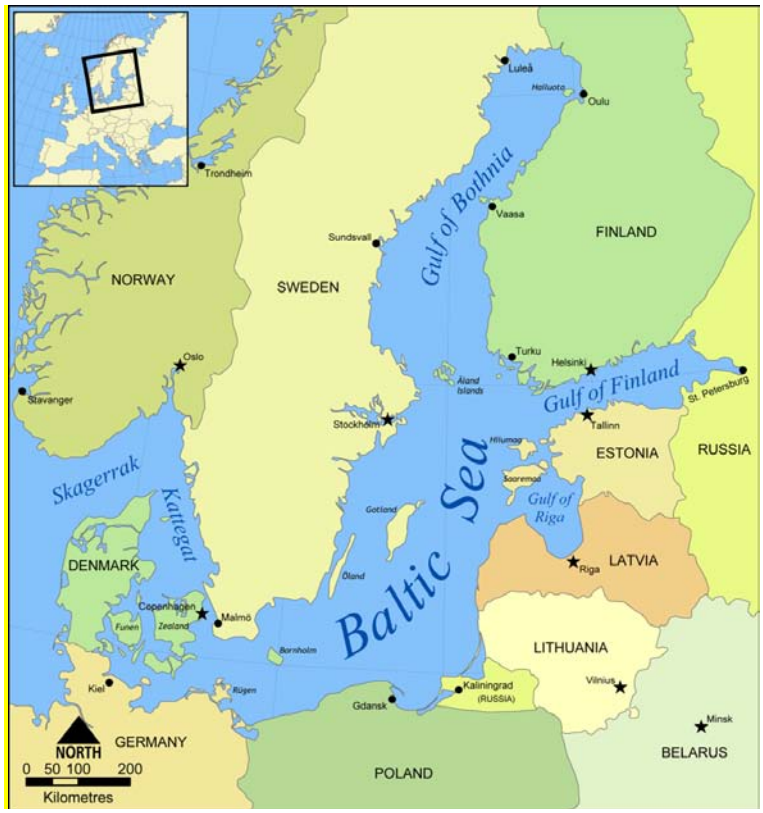

Figure 3: Baltic Sea Region (Map from Wikimedia Commons).

A relatively large part of the demand in Fnnish and Estonian seaports are due transit traffic to/from Russia. Estonian seaports handle a great deal of Russian oil products. The port of Tallinn handles over 20 million tons of oil each year. The oil is transported to Tallinn via

railways. The ports of Hamina and Kotka also handle a good deal of Russian oil products. The east-bound transit to Russia consists mostly from containers and cars. (Kämäräinen 2010; Posti et al. 2009)

SIMULATION MODEL

The simulation model combines Agent-Based Modelling with Discrete-Event Simulation. The model was coded using Anylogic. The main elements in the simulation model are the individual ships. Each ship represents one container ship, which has its own route to follow. The data for the ships has been gathered from Fossey (2009). The ships move in the Baltic Sea Region according to their route. When a ship arrives to its location, it spends there a stochastic amount of time. The time comes from a triangular distribution with a minimum time of 8 hours, mode of 12 hours, and a maximum of 24 hours. Figure 4 shows a schematic of the ship agents.

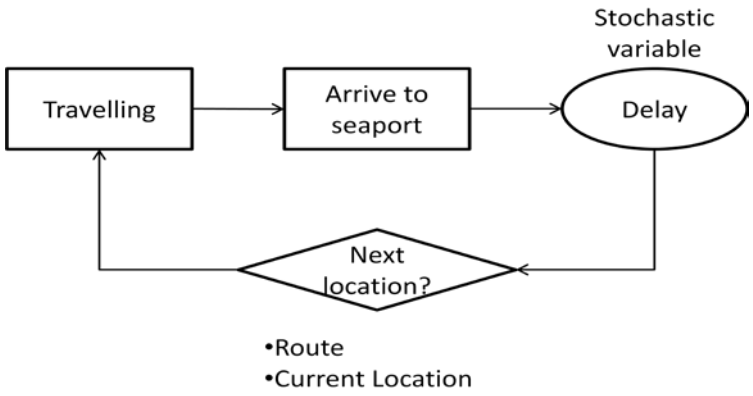

Figure 4: Schematic of the ship agents.

The travelling time uses a graphical information system (GIS) to calculate the time between the seaports using a fixed speed. The model contains a layer of networked connections in the region. This layer works as the GIS inside the model. The software has automatic algorithms, which choose the fastest route inside the network between the desired nodes. The layer is also incorporated to the user interface and the individual ships move on this layer. This is presented in Figure 5.

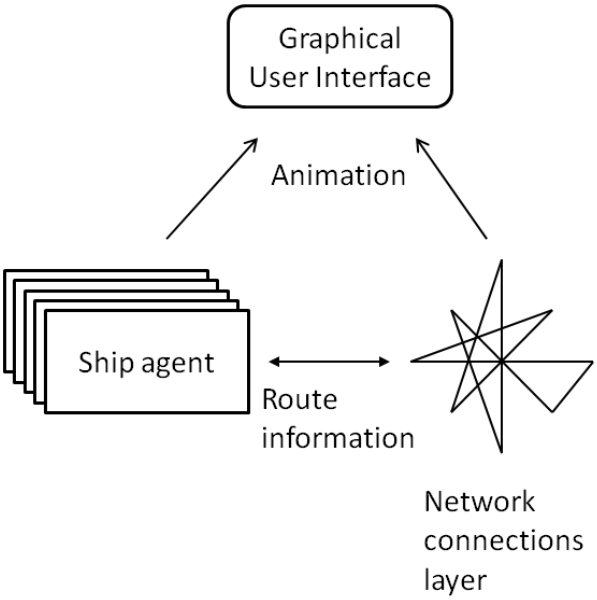

Figure 5: Schematic of the ship agents, network connections layer and graphical user interface.

During the normal run time no seaport has any issues with capacity. This is why the delays in the ship agents are modelled using stochastic variables. Figure 6 shows the model during the normal run-time.

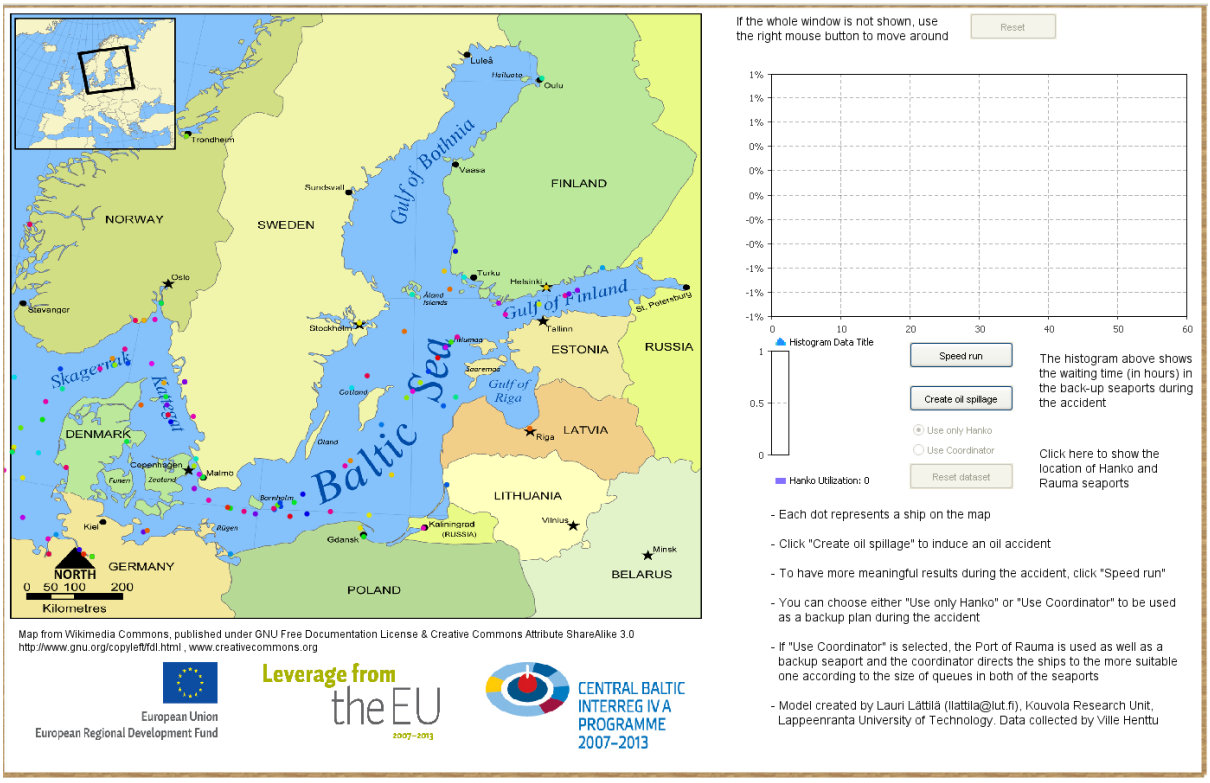

Figure 6: Model interface during normal runtime.

During the simulation it is possible to induce an oil accident in the region. The ports of Helsinki, Kotka, and Hamina cannot be used as the oil is seen to block the seaport completely. The ships start to re-route to Hanko as it is the closest seaport with a meaningful amount of container capacity. It is also possible to use a coordinating agent during the accident. This coordinator is able to gather information from various sources and in the Finnish context it could represent the Finnish National Emergency Supply Agency. The co-ordinator will route the ships to the most suitable location during the crisis. The co-ordinator will use Rauma as another potential backup seaport. It has a lot of container capacity but it is located further away on the west coast of Finland. The information used by the co-ordinator is presented in Table 2.

Table 2: Information used by the coordinator.

Amount of ships in Hanko
Amount of ships in Rauma
Ships arriving to Hanko
Ships arriving to Rauma
Capacity available at both seaports

During the oil-accident the capacity of Hanko and Rauma becomes constrained. The capacity of the seaports depends on the amount of container cranes on the seaports, as well as the working hours. In Finland seaports generally operate two shifts during weekdays and one shift during Saturday. Hanko has 2 cranes operating and Rauma has 9. Also, the seaports do some overtime work. Each ship will be handled even if the seaport has to use overtime.The model contains a graphical-user interface where the user can induce the oil accident. Also, the user can decide whether a coordinator is used or not. Figure 7 shows the model during the oil-accident.

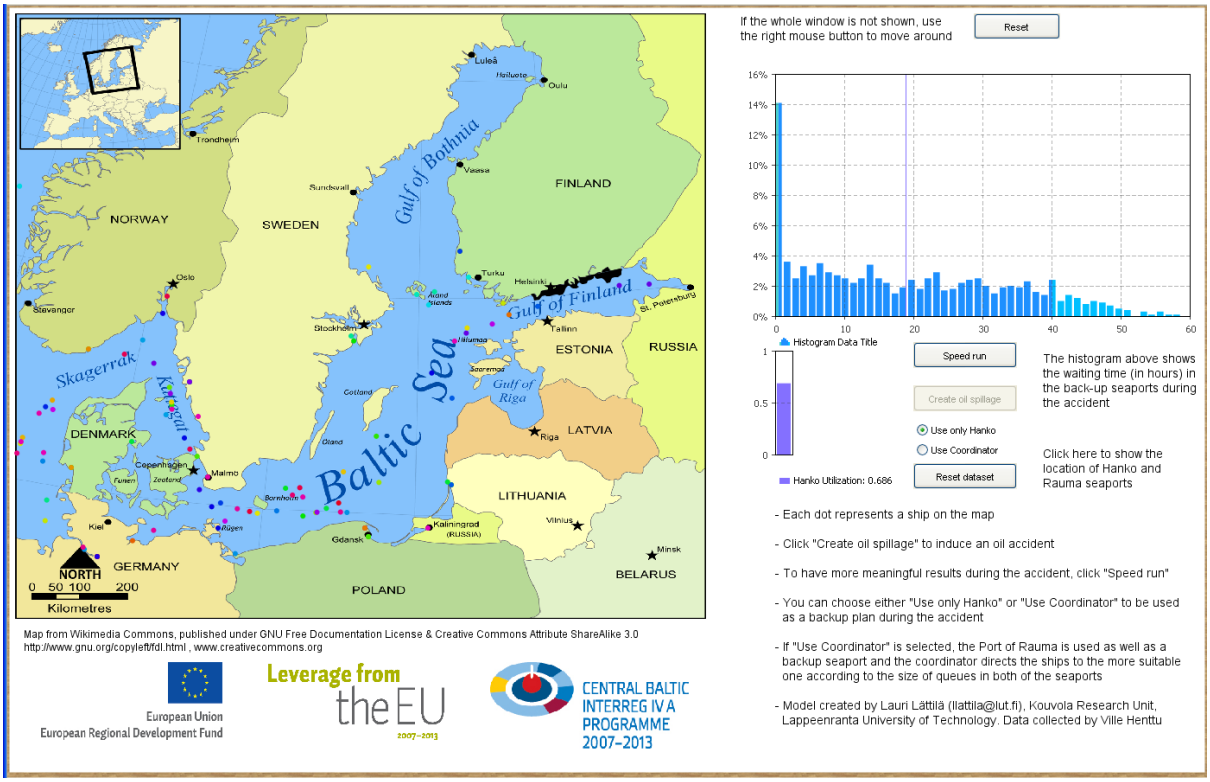

Figure 7: Model interface during the oil accident.

The ports of Rauma and Hanko are modeled using DES. The ships will first arrive into a queue and wait for a server. During the normal working hours all of the servers are available. Figure 8 shows the schematic for the ship agents during the oil accident

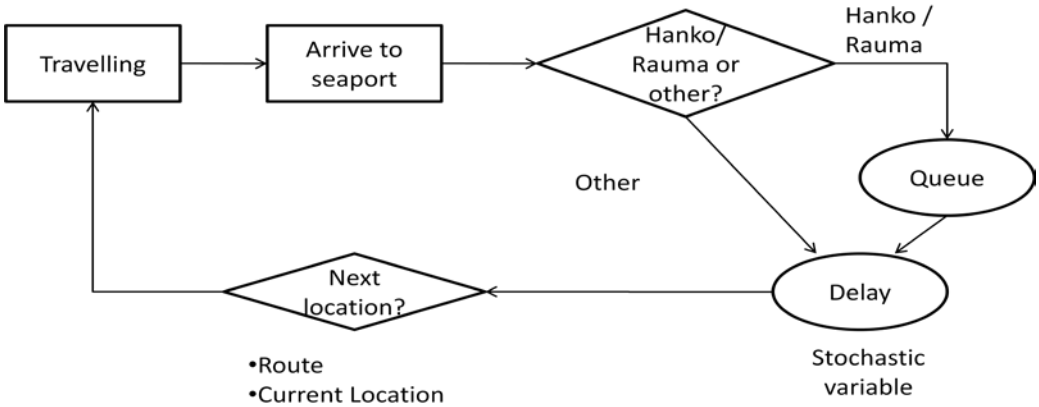

Figure 8: Schematics for the ship agents during the oil accident.

All of the ships at the port of Kotka, Hamina, and Helsinki are “trapped” inside the oil and cannot leave their respective seaports. They are removed from the model. The other ships start to reroute to Hanko or ask the coordinator for the appropriate seaport.

RESULTS FROM THE MODEL

The main area of interest in the simulation study is the queuing time in the system during the accident. In the long run the demand is below the system's capacity as the amount of ship is limited. However, the ships might have to wait long times before the seaports can take the ships in during the accident. Figure 9 shows results during one simulation run.

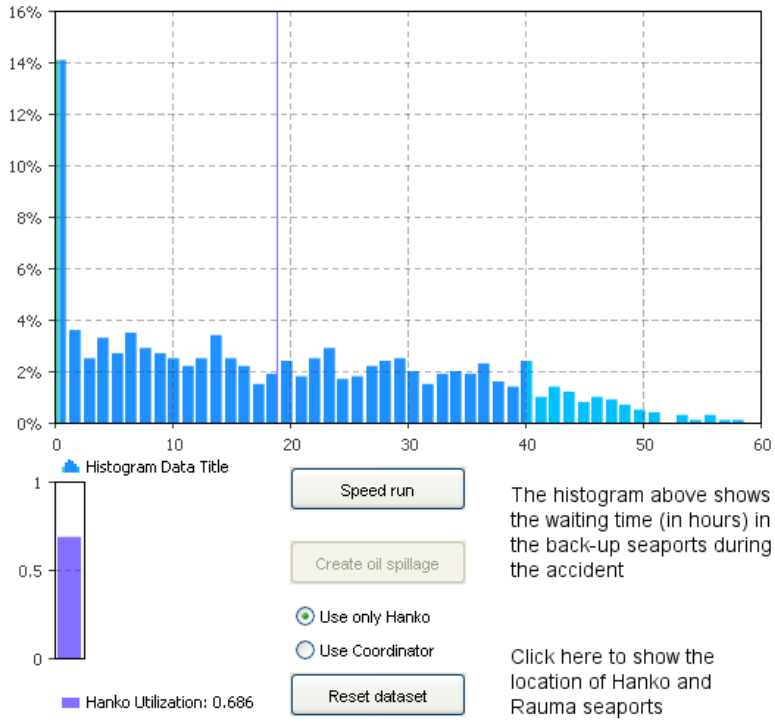

Figure 9: Waiting times for ships when only Hanko is used.

About 14% of the ships get immediately to handling as there are no ships in queue. However, most of the ships have to wait for some time and the average waiting time is 19 hours. Some ships even have to wait nearly 60 hours. It should be noted, that some of the waiting time is simply due to weekends. During this time no servers will be available and this is shown up as excess waiting time. The situation improves significantly when the coordinator is included in the model. The results for this are presented in Figure 10.

The average waiting time drops from 19 hours to ten hours. Also, as this situation also includes the seaport operating hours, large part of the queue is most likely due to waiting for working hours, not waiting for a server. Nearly 45% of the ships do not have to wait in queue at all.

The waiting time were compared statistically. As the waiting times are not normally distributed, a non-parametric test was chosen. In this case Mann-Whitney's U-test was used. The test was conducted with SPSS and the results are presented in Table 3.

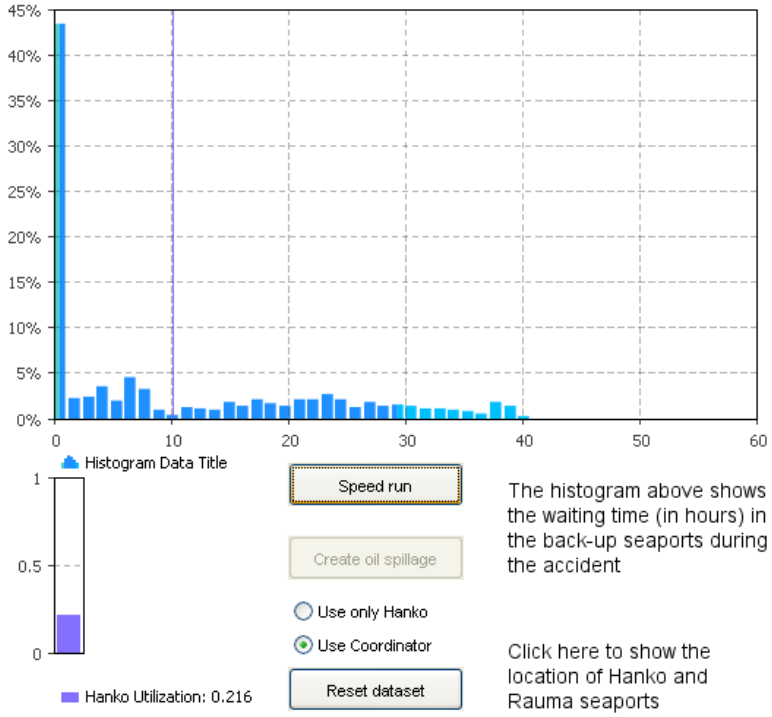

Figure 10: Waiting time for ships when coordinator is used.

Table 3: Mann-Whitney's test for the waiting times.

Ranks

	Chosen scenario	N	Mean Rank	Sum of Ranks
Excess waiting time	No coordinator	1000	1162,49	1162494,50
	Coordinator	1000	838,51	838505,50
	Total	2000		

Test Statistics[a]

	Excess waiting time
Mann-Whitney U	338005,500
Wilcoxon W	838505,500
Z	-12,680
Asymp. Sig. (2-tailed)	,000

a. Grouping Variable: Chosen scenario

The waiting times are clearly smaller when the coordinator is used. The ships are able to get through the system a lot faster and the damage to society is clearly smaller. However, in order to have more meaningful results, a Monte Carlo module was included in the model. The module will create oil accidents of various length and analyzes the mean waiting time. These results are presented in Figures 11 and 12.

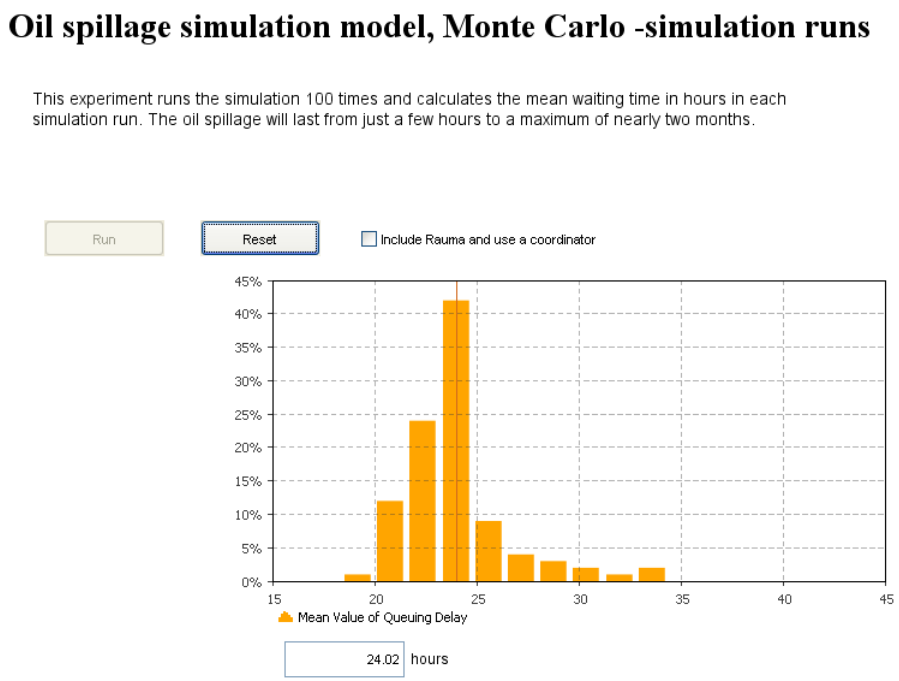

Figure 11: Monte Carlo run results without using a coordinator.

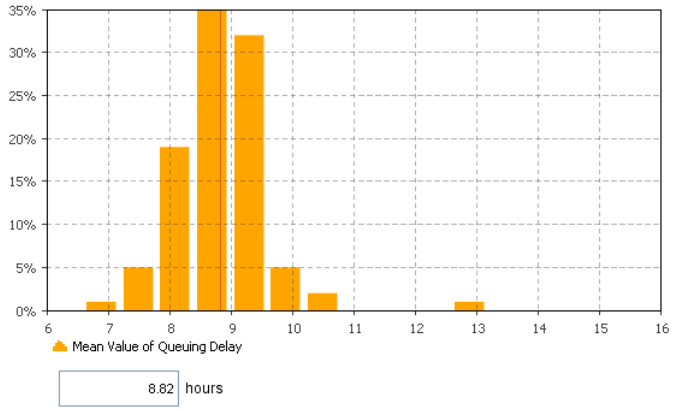

Figure 12: Monte Carlo run results with using a coordinator.

The Monte Carlo runs results confirm the observations. It is possible to significantly reduce the excess waiting time by using a coordinating actor who gathers the relevant information regarding potential back-up seaports. This is also reflected in the respective utilization statistics. Using only Hanko the utilization can be as high as over 70% (theoretical maximum without overtime is 52 % so significant over time is used in the model) but drops to 25 %, when a coordinator is used.

DISCUSSION AND CONCLUSIONS

The research question in this paper was "How can logistics emergency situations be simulated with Agent-Based Modelling?" Hybridization of ABM and DES seems to provide a good platform to analyze logistical systems in emergency situations. Individual nodes (such as seaports and warehouses) can be modeled using servers and queues, while actual transportation between the nodes can be modeled using ABM. This is in line with the

conceptual framework presented in Figure 2. Simulation provides a good way to estimate the interconnectness of the system as individual supply chain are connected. Supply chains can share same transports (especially large container ships) and they can use the same nodes. Coordination was also included in the model.

This research has some limitations. Firstly, only containerships in the Containerization International Yearbook were analyzed. If a significant portion of containerships are not presented in the book, then the demand on the seaports is too small. Also, different types of cargo were not analyzed in the model. Even though dry or liquid bulk ships would not use the same loading/unloading equipment, they require pilots to get to the seaports. Piloting should be as well included in the model and then incorporate demand from other sea vessels than container ships. Secondly, hinterland capacity was not analyzed in the model. This might create bottlenecks in the nodes, which would further increase the waiting time at the seaports.

Further research includes expanding the model to include different types of ships and pilots. However, it might be difficult to get information from the dry bulk shipping lines. One possible way is to include them as random arrivals to the servers according to the seaport current demand. Hinterland capacity also plays a vital role in emergency situations. It should also be included in the model. Hybridization of various simulation approaches provides many benefits and should be strongly encouraged in logistics research.

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THE SINGLE ITEM LOT SIZING PROBLEM WITH FUZZY PARAMETERS: A POSSIBILITY APPROACH

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ABSTRACT

The main objective of this paper is to deal with a single item lot sizing problem with fuzzy parameters, which is called the fuzzy single item lot sizing problem (F-SILSP). Since F-SILSP does not meet the crisp deterministic assumption, it cannot be solved by traditional mathematical programming. In this paper, the possibility approach is chosen to convert the fuzzy model to be an equivalent crisp single item lot sizing problem (EC-SILSP). The equivalent crisp model from this transformation procedure is in the form of mixed integer linear programming (MILP). It can be solved by traditional solver to find an optimal solution for each pre-specified possibility level. A numerical example with both trapezoidal and triangular fuzzy parameters is illustrated to demonstrate that an equivalent crisp model can be used. In addition, the equivalent crisp model is employed in inventory planning in a case study of inventory planning for bituminous coal with trapezoidal fuzzy demand and triangular fuzzy unit price in a power plant of an example petrochemical company.

Keywords: Modeling, Inventory Planning, Lot Sizing Problem, Fuzzy Set Theory, Possibility Theory, Petrochemical Company

INTRODUCTION

Lot sizing problems are production planning problems with order quantity between purchasing or production lots (Brahimi *et al.*, 2006). Small lot sizes lead to many orders and low inventory levels. On the other hand, big lot sizes lead to few orders and high inventory levels (Lee *et al.,* 1991). Thus, the consideration of lot sizes is an economic problem in that the objective of inventory models is to minimize total inventory cost, which comprises unit price, ordering cost, and inventory holding cost, while satisfying demand (Lee *et al.,* 1991; Brahimi *et al.*, 2006). The first inventory planning model, namely Economic Order Quantity (EOQ), was proposed by Harris (1913). It is used to find an optimal order quantity in the case of an uncapacitated single stage and single item of inventory control with a well-defined demand pattern. However, sometimes the demand pattern cannot be defined. Wagner and Whitin (1958) proposed an inventory model with time-vary demand, namely dynamic lot sizing, and used dynamic programming techniques to find an optimal order quantity. Subsequently, other inventory models have been constructed, based on the above models, such as the Economic Manufactured Quantity (EMQ) model, the EOQ with backorder, the EOQ with price breaks, EOQ based period order quantity, the EOQ for multiple items with capacity constraints, the lot sizing problem for lead time minimization, the run-out time

model, the lot sizing problem in the case of shortages causing lost sales, the order-level system with a power demand pattern, the uncapacitated single item lot sizing problem, the capacitated single item lot sizing problem, the uncapacitated multiple item lot sizing problem, the capacitated multiple item lot sizing problem, and so on (Baracsi *et al.*, 1990; Askin and Goldberg, 2002; Brahimi *et al.*, 2006).

USILSP is a type of inventory model with time-vary demand. Brahimi *et al.* (2006) stated that there are four basic formulations of USILSP in the form of mixed integer linear programming (MILP), i.e., aggregate formulation (AGG), formulation without inventory variables (NIF), the shortest path formulation (SHP), and facility location-based formulation without inventory variables (FAL). They gave three reasons that motivate us to study USILSP, i.e., some industries can aggregate products to obtain a single product, USILSP is a basic model and can be extended towards a more complex model, and many solution approaches for solving complex lot sizing problems must use USILP as sub-problems. As a result, the authors focus on the AGG model in USILSP which is shown in equations (1)-(4).

Notations

The following notations are used in the paper:

t, the t^{th} period in the planning horizon t = 1, 2,…, T,
y_t, the ordering (or setup) variable, which is 1 when order or setup occurs in period t, and 0 otherwise,
S_t, the ordering (or setup) cost in period t,
x_t, the purchasing (or producing) quantity in period t,
I_t, the inventory level at the end of period t,
p_t, the unit price (or production cost) in period t,
h_t, the inventory holding cost in period t,
d_t, the demand in period t,
d_{kT}, the sufficiently large number, where $d_{kT} = \sum_{t=1}^{T} d_t$; ∀t.

Focused on the AGG model in USILSP, assume that there are no beginning and ending stocks of the planning horizon ($I_0 = I_T = 0$), and inventory parameters i.e., s_t, p_t, h_t, and d_t are deterministic. The AGG of USILSP in a form of MILP is as follows:

(USILSP-AGG) Min TC = $\sum_{t=1}^{T}(s_t y_t + p_t x_t + h_t I_t)$ (1)

Subject to:

$I_{t-1} + x_t - I_t = d_t$; ∀t, (2)

$y_t d_{kT} \geq x_t$; ∀t, (3)

$y_t \in$ binary variables, $x_t \geq 0$, $I_t \geq 0$; ∀t. (4)

The objective function of USILSP-AGG in equation (1) is to minimize the total cost over the t period horizon. Constraints in equation (2) are inventory balance equations. Demand in period t (d_t) can be satisfied when it is equal to the beginning inventory of period t (I_{t-1}) plus the purchasing or producing quantities in period t (x_t) minus the available on-hand inventory at the end of period t (I_t). Constraints in equation (3) are used to control ordering variables. Since d_{tT} is a large number, then y_t is treated as 1 when inventory is ordered in period t ($x_t > 0$), and y_t is treated as 0 when inventory is not ordered in period t ($x_t = 0$).

To answer how much inventory is required to minimize total cost and satisfy demand in each period, the inventory models are a good choice of approach. When a classical inventory model is used, a crisp deterministic assumption is required. However, sometimes, this assumption does not hold. In real-world problems, there are two types of uncertain parameter in the inventory model, i.e., randomness and fuzziness, which respectively lead to the fuzzy inventory model and the stochastic inventory model. Most information stochastic inventory models are described by statistical or probabilistic information, which deals with probability distributions of inventory parameters. Since statistical information is collected from a lot of sampling data, high cost and time lost for data collection must be considered. There are many researchers who use verbal information based on the experiences of veterans, and model these experiences to be fuzzy parameters (Mandal *et. al.*, 2005; Yao *et al.,* 2006; Dutta *et. al.*, 2007; Tutuncu *et. al.*, 2008). For these reasons, this paper used fuzzy set theory and deals with SILSP with fuzzy parameters.

FUZZY UNCAPACITATED SINGLE ITEM LOT SIZING PROBLEM (F-USILSP)

Fuzzy set theory was first proposed by Zadeh (1965). It is a mathematical tool to describe imprecision in the fuzzy environment. Imprecision refers to the sense of vagueness rather than the lack of knowledge about the value of parameters. The vagueness is due to the unique experiences and judgments of decision makers. For example, demand is classified as two verbal sets, medium and high. When a classical set is chosen to classify this demand as verbal classes, the range of 10,000-15,000 units of demand is defined as medium, and 15,001-20,000 units of demand is defined as high. The exact boundary of medium and high is 15,000 units of demand. It means that 15,000 units of demand is assigned to the set of medium, but 15,001 units of demand is assigned to the set of high. This classification shows that when an event is classified by the judgment of decision maker(s), an exact set boundary is inappropriate. On the other hand, the fuzzy set boundary is not an exact demarcation but an area of boundary. Members in a fuzzy set must be linked with a degree of possibility in the range of [0, 1], which is called a membership function.

The fuzzy set was designed for vagueness and uncertainty, which are found in real life. In addition, there are many fields which are built based on fuzzy set theory, such as fuzzy logic and control, fuzzy clustering, fuzzy mathematical programming , etc. (Zimmermann, 1996). Fuzzy mathematical programming or fuzzy optimization, which was proposed by Zimmermann (1976, 1978, and 1983), is one application of fuzzy set theory. It was extended to many fields in production planning and control, such as transportation, scheduling, flexible manufacturing system (FMS), location, aggregate planning, inventory planning, and

so on (Zimmermann, 1996; Klir *et al.*, 1997). There has been a lot of research which deals with vagueness in inventory models. For example, Yao and Lee (1999) introduced a group of computing schemata for the fuzzy EOQ of inventory with or without backorders. Hsieh (2002) used fuzzy arithmetical operations of the function principle to find the fuzzy total production inventory costs, and used Graded Mean Integration Representation and the Extension of the Lagrangean method to defuzzify and find optimal solutions for the inventory models. Pai (2003) applied fuzzy sets theory to solve capacitated lot size problems with fuzzy capacity. Yao and Chiang (2003) compared the results obtained by centroid and signed distance methods in the case of the total cost of inventory without backorders. Mandala *et al.* (2005) focused on fuzzy cost parameters, objective functions, and constraints in a multi-item multi-objective inventory model with shortages and demand dependent unit cost with storage space, number of orders and production cost restrictions. Chang *et al.* (2006) used fuzzy concepts to optimize total inventory cost in the case of a mixture inventory model involving variable lead time with backorders and lost sales. Chen and Chang (2008) studied the fuzzy EPQ in the case of unrepairable defective products with fuzzy opportunity cost and trapezoidal fuzzy costs under crisp or fuzzy production quantities in order to extend the traditional production inventory model to the fuzzy model. Halim *et al.* (2011) developed fuzzy production planning models for an unreliable production system with fuzzy production rate and stochastic/fuzzy demand rate.

The AGG model is selected to show how the possibility approach can transform the fuzzy inventory model into an equivalent crisp inventory model. Let the unit price, ordering cost, inventory holding cost, and demand be fuzzy variables. Thus the F-USILSP can be modeled as follows:

$$\text{(F-USILSP) Min TC} = \sum_{t=1}^{T}(\tilde{s}_t y_t + \tilde{p}_t x_t + \tilde{h}_t I_t) \quad (5)$$

$$\text{Subject to } I_{t-1} + x_t - I_t = \tilde{d}_t;\ \forall t, \quad (6)$$

$$y_t \tilde{d}_{kT} \geq x_t;\ \forall t, \quad (7)$$

$$y_t \in \text{binary variables},\ x_t \geq 0,\ I_t \geq 0;\ \forall t. \quad (8)$$

The F-USILSP in equations (5)-(8) is in a form of fuzzy MILP. Thus, this model cannot be solved by classical mathematical methods.

EQUIVALENT CRISP UNCAPACITATED SINGLE ITEM LOT SIZING PROBLEM (EC-USILSP)

The possibility approach in the context of fuzzy set theory was introduced by Zadeh (1978) to deal with non- stochastic imprecision and vagueness. According to Dubois and Prade (1988) and Dubois (2006), the possibility approach appropriately was used to model various kinds of information, such as linguistic information and uncertain formulae, in logical settings. In this section, the possibility approach will be used to convert the F-USILSP to the EC-USILSP.

Let $\tilde{a}$ and $\tilde{b}$ be fuzzy variables, and $\tilde{a}'$ and $\tilde{b}'$ be the complements of $\tilde{a}$ and $\tilde{b}$, respectively. Operation * means any one of the operators >, $\geq$, =, $\leq$, <. The possibility and necessity measure of fuzzy event $\tilde{a} * \tilde{b}$ are respectively defined by (Zimmermann, 1990).

$$\pi(\tilde{a} * \tilde{b}) = \sup\{\min(\mu_{\tilde{a}}(x), \mu_{\tilde{b}}(y))/x * y; x, y \in \Re\} \quad (9)$$

$$\mathrm{Ness}(\tilde{a} * \tilde{b}) = 1 - \pi(\tilde{a}' * \tilde{b}') \quad (10)$$

where $\pi(\tilde{\bullet})$ and $\mathrm{Ness}(\tilde{\bullet})$ means possibility and necessity of fuzzy variable $\tilde{\bullet}$.

Let $\tilde{a}_i$ for i = 1,…, n be n fuzzy variables, the right hand side $\tilde{b}$ becomes a crisp variable, and let $f : \Re^n \to \Re$ be a real-value function. The possibility of fuzzy event $f(\tilde{a}_i) * b$ is defined by (Zimmermann, 1996).

$$\pi(f(\tilde{a}_i) * b) = \sup_{x_i \in \Re}\{\min_{1 \leq i \leq n}\{\mu_{\tilde{a}_i}(x_i)\} / f(x_i) * b; x_i, b \in \Re, \forall i\} \quad (11)$$

In this paper, Chance-Constrained Programming (CCP) (Charnes and Cooper, 1959), which is normally used to confront stochastic linear programming (SLP), is adopted as a way to convert the F-USILSP to the EC-USILSP. The concept of CCP guarantees that the probability of stochastic constraints is greater than or equal to a pre-specified minimum probability. Let $\hat{c}_j$, $\hat{a}_{ij}$, and $\hat{b}_i$ for j = 1, …, n and i = 1, …,m be continuous random variables, and x_j be decision variables. The relationship between standard SLP and its probability SLP is given by Min Z = $\sum_{j=1}^{n} \hat{c}_j x_j$; subject to constraints, $\sum_{j=1}^{n} \hat{a}_{ij} x_j \leq \hat{b}_i$; $x_j \geq 0$ for all x_j if and only if Min Z = f; $\Pr\left(\sum_{j=1}^{n} \hat{c}_j x_j \leq f\right) \geq 1 - \alpha$; $\Pr\left(\sum_{j=1}^{n} \hat{a}_{ij} x_j \leq \hat{b}_i\right) \geq 1 - \alpha_i$; f and $x_j \geq 0$ for all x_j, where f is an artificial variable, which should be the minimum value when it is not greater than the objective function of standard SLP, Pr means probability, $1 - \alpha$ and $1 - \alpha_i$ are pre-specified minimum probabilities. The researchers who are interested in the field of SLP can refer to Birge and Louveaux (1997) for further details. In the same way, the F-USILSP becomes the following possibility USILSP:

(Poss-USILSP) Min TC = Θ (12)

Subject to $\pi\left(\sum_{t=1}^{T} (\tilde{s}_t y_t + \tilde{p}_t x_t + \tilde{h}_t I_t) \leq \Theta\right) \geq \alpha$; $\forall t$, (13)

$$\pi(I_{t-1} + x_t - I_t = \tilde{d}_t) \geq \alpha; \forall t, \quad (14)$$

$$\pi(y_t \tilde{d}_{kT} \geq x_t) \geq \alpha; \forall t, \quad (15)$$

$y_t \in$ binary variables, $x_t \geq 0$, $I_t \geq 0$, $\Theta \geq 0$; $\forall t$. (16)

Based on the possibility ranking in equation (11), Lertworasirikul *et al.* (2003) proved and proposed the Lemma 1, as follows:

Lemma1. Let $\tilde{a}_i$ for i = 1,..., n be fuzzy variables with normal and convex membership functions and b be a crisp variable. The lower and upper bounds of the α-level set of $\tilde{a}_i$ are denoted by $(\tilde{a}_i)_\alpha^L$ and $(\tilde{a}_i)_\alpha^U$, respectively. Then, for any given possibility levels α_1, α_2 and α_3 with $0 \le \alpha_1, \alpha_2, \alpha_3 \le 1$,

(i) $\pi(\tilde{a}_1 + \cdots + \tilde{a}_n \le b) \ge \alpha_1$ iff $(\tilde{a}_1)_{\alpha_1}^L + \cdots + (\tilde{a}_n)_{\alpha_1}^L \le b$,

(ii) $\pi(\tilde{a}_1 + \cdots + \tilde{a}_n \ge b) \ge \alpha_2$ iff $(\tilde{a}_1)_{\alpha_2}^U + \cdots + (\tilde{a}_n)_{\alpha_2}^U \ge b$,

(iii) $\pi(\tilde{a}_1 + \cdots + \tilde{a}_n = b) \ge \alpha_3$ iff $(\tilde{a}_1)_{\alpha_3}^L + \cdots + (\tilde{a}_n)_{\alpha_3}^L \le b$ and $(\tilde{a}_1)_{\alpha_3}^U + \cdots + (\tilde{a}_n)_{\alpha_3}^U \ge b$.

The Poss-USILSP is transformed into the EC-USILSP by the Lemma 1, as follows:

(EC-USILSP) Min TC = $$\sum_{t=1}^{T}\left((\tilde{s}_t)_\alpha^L y_t + (\tilde{p}_t)_\alpha^L x_t + (\tilde{h}_t)_\alpha^L I_t \right) \quad (17)$$

Subject to $I_{t-1} + x_t - I_t \ge (\tilde{d}_t)_\alpha^L$; $\forall t$, (18)

$I_{t-1} + x_t - I_t \le (\tilde{d}_t)_\alpha^U$; $\forall t$, (19)

$y_t (\tilde{d}_{kT})_\alpha^U \ge x_t$; $\forall t$, (20)

$y_t \in$ binary variables, $x_t \ge 0$, $I_t \ge 0$; $\forall t$. (21)

The special case of EC-USILSP, which is the EC-USILSP with trapezoidal and triangular fuzzy parameters, will be shown in next section.

EC-USILSP WITH TRAPEZOIDAL AND TRIANGULAR FUZZY NUMBERS

Since trapezoidal and triangular fuzzy numbers, which have linear membership functions, are basically fuzzy numbers, the F-USILSP with trapezoidal and triangular parameters will be examined in this paper. Let $\tilde{A}$ be the trapezoidal fuzzy number with a lower and upper crisp value at α = 0 and 1 at each corner point of trapezoidal membership function, which is denoted by $(\tilde{A})_0^L$, $(\tilde{A})_1^L$, $(\tilde{A})_1^U$, and $(\tilde{A})_0^U$, respectively (See Figure 1a). The membership function of $\tilde{A}$ is given by

$$\mu_{\tilde{A}}(r)=\begin{cases}\dfrac{r-(\tilde{A})_0^L}{(\tilde{A})_1^L-(\tilde{A})_0^L} & ;(\tilde{A})_0^L\le r\le(\tilde{A})_1^L\\ 1 & ;(\tilde{A})_1^L\le r\le(\tilde{A})_1^U\\ \dfrac{r-(\tilde{A})_0^U}{(\tilde{A})_1^U-(\tilde{A})_0^U} & ;(\tilde{A})_1^U\le r\le(\tilde{A})_0^U\\ 0 & ;\text{Otherwise}\end{cases} \quad (22)$$

where $\mu_{\tilde{A}}(r) \in [0, 1]$, and $r \in \mathbb{R}$. Thus, the lower and upper crisp value of $\tilde{A}$ at each α-cut are defined by $r_{Lower/\tilde{A}} = (\tilde{A})_1^L\alpha+(\tilde{A})_0^L(1-\alpha)$, and $r_{Upper/\tilde{A}} = (\tilde{A})_1^U\alpha+(\tilde{A})_0^U(1-\alpha)$. Let $\tilde{B}$ be a trapezoidal fuzzy number with $(\tilde{B})_1^L = (\tilde{B})_1^U = (\tilde{B})_1$, then $\tilde{B}$ is called a triangular fuzzy number (see Figure 1b). The lower and upper crisp value of $\tilde{B}$ at each α-cut are defined by $r_{Lower/\tilde{B}} = (\tilde{B})_1\alpha+(\tilde{B})_0^L(1-\alpha)$, and $r_{Upper/\tilde{B}} = (\tilde{B})_1\alpha+(\tilde{B})_0^U(1-\alpha)$.

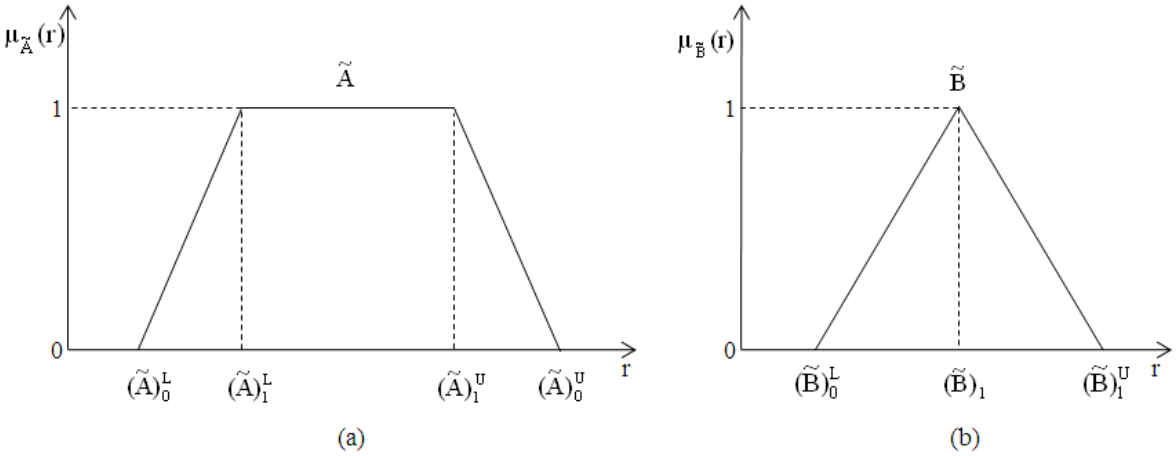

Figure 1: Membership Function of (a) Trapezoidal Fuzzy Number, and (b) Triangular Fuzzy Number

If the fuzzy parameters of F-USILSP $\tilde{s}_t$, $\tilde{p}_t$, $\tilde{h}_t$ and $\tilde{d}_t$ are trapezoidal fuzzy numbers, then the general model of EC-USILSP follows mixed integer linear programming.

$$\text{(EC-USILSP-Trapezoidal) Min TC} = \sum_{t=1}^{T}\left(\left(\alpha(\tilde{s}_t)_1^L+(1-\alpha)(\tilde{s}_t)_0^L\right)y_t+\left(\alpha(\tilde{p}_t)_1^L+(1-\alpha)(\tilde{p}_t)_0^L\right)x_t+\left(\alpha(\tilde{h}_t)_1^L+(1-\alpha)(\tilde{h}_t)_0^L\right)I_t\right) \quad (23)$$

$$\text{Subject to } I_{t-1}+x_t-I_t \ge \alpha(\tilde{d}_t)_1^L+(1-\alpha)(\tilde{d}_t)_0^L;\ \forall t, \quad (24)$$

$$I_{t-1}+x_t-I_t \le \alpha(\tilde{d}_t)_1^U+(1-\alpha)(\tilde{d}_t)_0^U;\ \forall t, \quad (25)$$

$$y_t\left(\alpha(\tilde{d}_{kT})_1^U + (1-\alpha)(\tilde{d}_{tT})_0^U\right) \geq x_t \text{; } \forall t, \quad (26)$$

$y_t \in$ binary variables, $x_t \geq 0$, $I_t \geq 0$; $\forall t$, (27)

Note that a triangular fuzzy number is a trapezoidal fuzzy number with $(\tilde{\bullet})_1^L = (\tilde{\bullet})_1^U$. Thus, EC-USILSP with triangular fuzzy parameters can be modeled as EC-USILSP with triangular fuzzy parameters. The numerical example with triangular fuzzy parameters is illustrated to show how to use this model in the next section.

NUMERICAL EXAMPLE

To show how to use the EC-USILSP model, a numerical example with trapezoidal fuzzy unit price and demand and triangular fuzzy inventory holding and ordering cost is discussed in this section. Assume that the beginning and ending stock of the planning horizon are both zero. Let the trapezoidal fuzzy unit price be classified as three levels, i.e., cheap, normal and expensive. It is respectively denoted by $\tilde{p}_c$ = (10, 15, 20, 25), $\tilde{p}_n$ = (20, 25, 30, 35), and $\tilde{p}_e$ = (30, 35, 40, 45). The trapezoidal fuzzy demand is classified as three levels, i.e., low, medium, and high. It is respectively denoted by $\tilde{d}_l$ = (60, 80, 100, 120), $\tilde{d}_m$ = (100, 120, 150, 170), and $\tilde{d}_h$ = (150, 170, 180, 200). The triangular fuzzy ordering cost is classified as three levels, i.e., low, medium, and high. $\tilde{s}_l$ = (200, 300, 400), $\tilde{s}_m$ = (300, 400, 500), and $\tilde{s}_h$ = (500, 600, 700). The triangular fuzzy inventory holding cost is classified as three levels, i.e., low, medium, and high. $\tilde{h}_l$ = (1, 2, 3), $\tilde{h}_m$ = (2, 3, 4), and $\tilde{h}_h$ = (3, 4, 5). Based on the experience of the decision maker, the parameter levels of the F-USILSP in terms of the verbal classification for five periods are shown in Table 1.

Table 1: Verbal Estimation of F-USILSP parameters for Five Periods.

Period t	Unit Price	Demand	Ordering Cost	Holding Cost
1	Cheap	Medium	Medium	High
2	Expensive	High	High	Medium
3	Cheap	Low	Low	High
4	Normal	Medium	Low	Medium
5	Expensive	High	High	Low

From Table 1, the F-USILSP of this example is modeled as follows:

$$\begin{aligned}\text{(F-USILSP) Min TC} = {} & (\text{Medium})y_1 + (\text{High})y_2 + (\text{Low})y_3 + (\text{Low})y_4 + (\text{High})y_5 \\ & + (\text{Cheap})x_1 + (\text{Expensive})x_2 + (\text{Cheap})x_3 + (\text{Normal})x_4 + (\text{Expensive})x_5 \\ & + (\text{High})I_1 + (\text{Medium})I_2 + (\text{High})I_3 + (\text{Medium})I_4 + (\text{Low})I_5 \quad (28)\end{aligned}$$

Subject to

$x_1 - I_1$ = Medium, (29) $I_1 + x_2 - I_2$ = High, (30)

$I_2 + x_3 - I_3$ = Low, (31) $I_3 + x_4 - I_4$ = Medium, (32)

$I_4 + x_5$ = High, (33) $y_1\tilde{d}_{15} \geq x_1$, (34)

$y_2\tilde{d}_{25} \geq x_2$, (35) $y_3\tilde{d}_{35} \geq x_t$, (36)

$y_4\tilde{d}_{45} \geq x_4$, (37) $y_5\tilde{d}_{55} \geq x_5$, (38)

$y_t \in$ binary variables, $x_t \geq 0$, $I_t \geq 0$ for t = 1, 2, …, 5 (39)

In accordance with the extension principle, fuzzy numbers $\tilde{d}_{tT}$ for all t = 1, …, T are given by $\tilde{d}_{15} = \left[\sum_{t=1}^{5}(\tilde{d}_t)_\alpha^L, \sum_{t=1}^{5}(\tilde{d}_t)_\alpha^U\right] = \left[\left(\alpha\sum_{t=1}^{5}(\tilde{d}_t)_1^L + (1-\alpha)\sum_{t=1}^{5}(\tilde{d}_t)_0^L\right), \left(\alpha\sum_{t=1}^{5}(\tilde{d}_t)_1^U + (1-\alpha)\sum_{t=1}^{5}(\tilde{d}_t)_0^U\right)\right]$, then the crisp interval of $\tilde{d}_{15}$ is $(\tilde{d}_{15})_\alpha^U = 760\alpha + 860(1-\alpha)$. So, $(\tilde{d}_{25})_\alpha^U = 610\alpha + 690(1-\alpha)$, $(\tilde{d}_{35})_\alpha^U = 430\alpha + 490(1-\alpha)$, $(\tilde{d}_{45})_\alpha^U = 330\alpha + 370(1-\alpha)$, and $(\tilde{d}_{55})_\alpha^U = 180\alpha + 200(1-\alpha)$. Thus, the EC-USILSP with triangular and trapezoidal parameters is a crisp MILP as follows:

(EC-USILSP) Min TC = $(400\alpha + 300(1-\alpha))y_1 + (500\alpha + 400(1-\alpha))y_2 + (300\alpha + 200(1-\alpha))y_3$
$+ (300\alpha + 200(1-\alpha))y_4 + (500\alpha + 400(1-\alpha))y_5 + (15\alpha + 10(1-\alpha))x_1 + (35\alpha + 30(1-\alpha))x_2$
$+ (15\alpha + 10(1-\alpha))x_3 + (25\alpha + 20(1-\alpha))x_4 + (35\alpha + 30(1-\alpha))x_5 + (4\alpha + 3(1-\alpha))I_1$
$+ (3\alpha + 2(1-\alpha))I_2 + (4\alpha + 3(1-\alpha))I_3 + (3\alpha + 2(1-\alpha))I_4 + (2\alpha + (1-\alpha))I_5$ (40)

Subject to

$x_1 - I_1 \geq 120\alpha + 100(1-\alpha)$, (41) $x_1 - I_1 \leq 150\alpha + 170(1-\alpha)$, (42)

$I_1 + x_2 - I_2 \geq 170\alpha + 150(1-\alpha)$, (43) $I_1 + x_2 - I_2 \leq 180\alpha + 200(1-\alpha)$, (44)

$I_2 + x_3 - I_3 \geq 80\alpha + 60(1-\alpha)$, (45) $I_2 + x_3 - I_3 \leq 100\alpha + 120(1-\alpha)$, (46)

$I_3 + x_4 - I_4 \geq 120\alpha + 100(1-\alpha)$, (47) $I_3 + x_4 - I_4 \leq 150\alpha + 170(1-\alpha)$, (48)

$I_4 + x_5 \geq 170\alpha + 150(1-\alpha)$, (49) $I_4 + x_5 \leq 180\alpha + 200(1-\alpha)$, (50)

$y_1(760\alpha + 860(1-\alpha)) \geq x_1$, (51) $y_2(610\alpha + 690(1-\alpha)) \geq x_2$, (52)

$y_3(430\alpha + 490(1-\alpha)) \geq x_3$, (53) $y_4(330\alpha + 370(1-\alpha)) \geq x_4$, (54)

$y_5(180\alpha + 200(1-\alpha)) \geq x_5$, (55)

$y_t \in$ binary variables, $x_t \geq 0$, $I_t \geq 0$ for t = 1, 2, …, 5 (56)

This above crisp mixed integer linear programming is solved with α = 0, 0.1, 0.2, …, 1. Then the total cost, ordering variable in period t, buying quantity in period t, and inventory level at the end of period t for t = 1, 2, …, 5 are shown in Table 2.

Table 2: The result of numerical example.

Alpha Level	Total Cost	Period t	y_t	x_t	I_t
0	7,600.00	1	1	250	150
		2	0	0	0
		3	1	310	250
		4	0	0	150
		5	0	0	0
0.1	8,082.80	1	1	254	152
		2	0	0	0
		3	1	316	254
		4	0	0	152
		5	0	0	0
0.2	8,577.20	1	1	258	154
		2	0	0	0
		3	1	322	258
		4	0	0	154
		5	0	0	0
0.3	9,083.20	1	1	262	156
		2	0	0	0
		3	1	328	262
		4	0	0	156
		5	0	0	0
0.4	9,600.80	1	1	266	158
		2	0	0	0
		3	1	334	266
		4	0	0	158
		5	0	0	0
0.5	10,130.00	1	1	270	160
		2	0	0	0
		3	1	340	270
		4	0	0	160
		5	0	0	0
0.6	10,670.80	1	1	274	162
		2	0	0	0
		3	1	346	274
		4	0	0	162
		5	0	0	0
0.7	11,223.20	1	1	278	164
		2	0	0	0
		3	1	352	278
		4	0	0	164
		5	0	0	0
0.8	11,787.20	1	1	282	166
		2	0	0	0
		3	1	358	282
		4	0	0	166
		5	0	0	0

		1	1	286	168
		2	0	0	0
0.9	**12,362.80**	3	1	364	286
		4	0	0	168
		5	0	0	0
		1	1	290	170
		2	0	0	0
1.0	**12,950.00**	3	1	370	290
		4	0	0	170
		5	0	0	0

From Table 2, at the lowest possible level ($\alpha = 0$), the inventory plan orders 250 units in period one to cover the first two periods and 310 units to cover periods three, four, and five. The total cost is 7,600.00 THB. At the highest possible level ($\alpha = 1$), the inventory plan orders 290 units in period one to cover the first two periods and 370 units to cover periods three, four, and five. The total cost is 12,950.00 THB. The trend of total cost from EC-USILSP, solving with $\alpha = 0, 0.1, 0.2, \ldots, 1$, is an increasing linear trend, which is illustrated by plotting TC and α in x and y axis, respectively. It means that when higher possible levels are required, the TC will increase.

CASE STUDY

The case study of this paper focuses on the inventory planning of bituminous coal in a power plant of a petrochemical company. The main purpose of this power plant is to produce electrical power for the company's petrochemical plants, which is the core business of this company. Bituminous coal is the main raw material for the generation of the electrical power. Demand for bituminous coal measured in metric tons is dependent on the demand for electrical power, which is required for petrochemical production. In this study, the demand for bituminous coal is classified as 5 trapezoidal fuzzy numbers, i.e., lowest, low, medium, high, and highest (see the membership function of fuzzy demand in Figure 2). Based on the experience of the production manager and the fuzzy information in Figure 2, the demand for bituminous coal in the planning horizon (12 periods) is predicted in the form of verbal demand, which is shown in Table 3. The price of bituminous coal per metric ton is classified as 7 triangular fuzzy numbers, i.e., the cheapest, very cheap, cheap, normal, expensive, very expensive, the most expensive (see the membership function of fuzzy unit prices in Figure 3). Based on the experience of the purchasing manager and the fuzzy information in Figure 3, the unit price of bituminous coal in the planning horizon is predicted in the form of verbal unit prices, which are shown in Table 3. The company has two outsourcers, namely companies A and B, which transport bituminous coal from the distributor to the inventory area. Focusing on the inventory area, there is a large area for the storage of 80,000 metric tons of bituminous coal. According to the company's policies, 20,000 metric tons of bituminous coal must be stored as a safety stock. It cannot be used up. Thus, the net inventory space is equal to 60,000 metric tons. The inventory level at the end of period 0, or the beginning stock of period 1, is equal to 15,000 tons. So the net demand of period 1 is equal to (20,000, 25,000, 30,000, 35,000) metric tons minus 15,000 metric tons, that is (5,000, 10,000, 15,000 20,000) metric tons. Company A charges 1 million Thai Baht (THB) per order, and the maximum transportation capacity of company A is 50,000 metric tons per period. Company B charges 1.5 million THB per order, and the

maximum transportation capacity of company B is equal to that of company A. Note that although the quantity of each order is less than the maximum transportation capacity of each company, companies A and B cannot discount the charge rate per order. Based on the policies of the company, the holding cost is fixed as a crisp value. It is equal to 200 THB per metric ton per period.

Table 3: Demand (x 1,000 Metric Tons) and Unit Price (x 100 THB per Metric Ton).

Period t	Demand		Unit Price	
	Verbal Prediction	Trapezoidal Fuzzy Number	Verbal Prediction	Triangular Fuzzy Number
1	Low	(20, 25, 30, 35)	Normal	(20, 25, 30)
2	Low	(20, 25, 30, 35)	Cheap	(15, 20, 25)
3	Medium	(30, 35, 40, 45)	Cheap	(15, 20, 25)
4	Medium	(30, 35, 40, 45)	Very Cheap	(10, 15, 20)
5	Medium	(30, 35, 40, 45)	Cheap	(15, 20, 25)
6	Medium	(30, 35, 40, 45)	Cheap	(15, 20, 25)
7	High	(40, 45, 50, 55)	Normal	(20, 25, 30)
8	High	(40, 45, 50, 55)	Expensive	(25, 30, 35)
9	Medium	(30, 35, 40, 45)	Normal	(20, 25, 30)
10	Low	(20, 25, 30, 35)	Expensive	(25, 30, 35)
11	Lowest	(15, 15, 20, 25)	Normal	(20, 25, 30)
12	Lowest	(15, 15, 20, 25)	Expensive	(25, 30, 35)

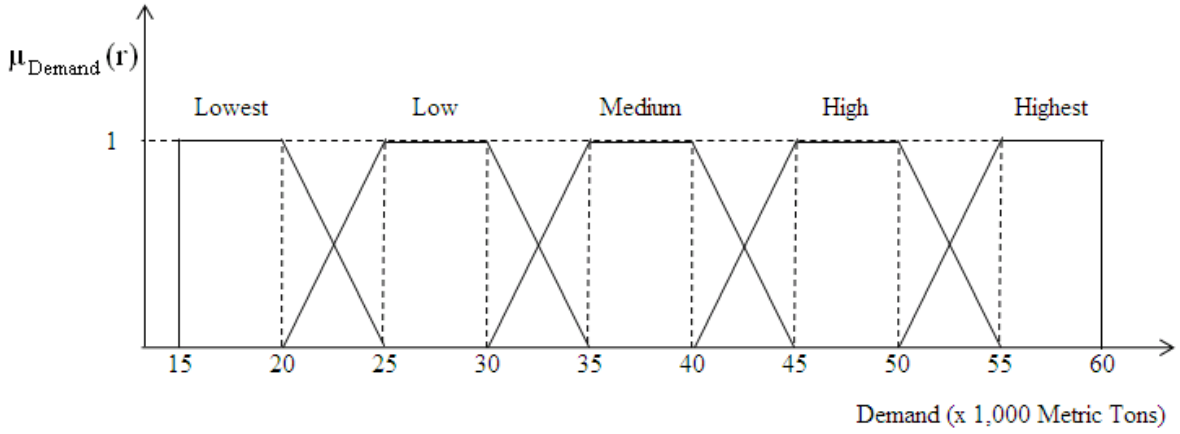

Figure 2: Membership Function of Fuzzy Demand.

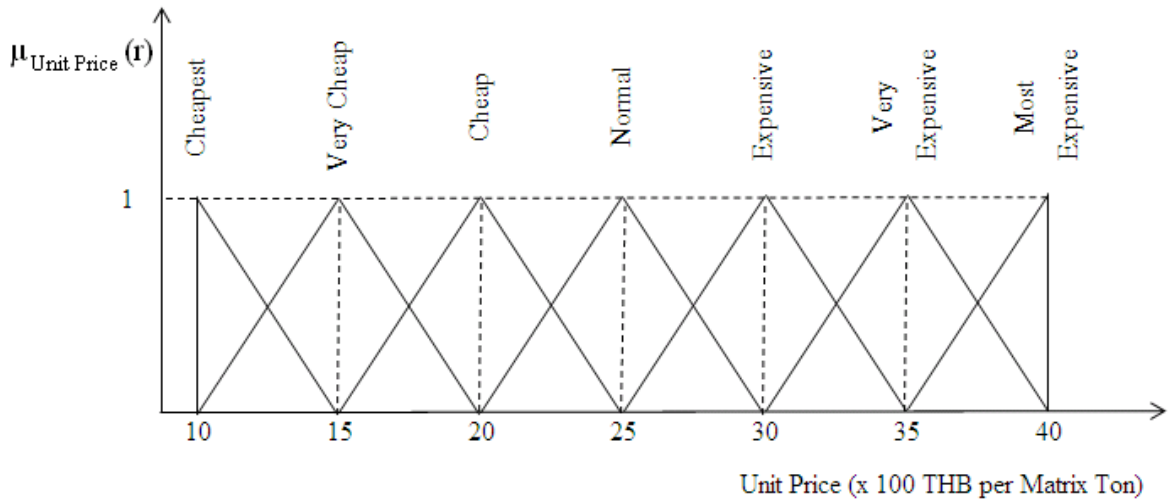

Figure 3: Membership Function of Fuzzy Unit Prices.

This case study is different from the numerical example. Since there are two transporters, and transportation capacity of them is limited, sometimes only company A can be selected (the service charge of company A is less than that of company B), but sometimes both companies A and B must be selected (when the buying quantity exceeds the transportation capacity of company A). Let decision variables x_{tA} and x_{tB} for t = 1,…, 12 be the buying quantities which are transported by companies A and B in period t, respectively. Thus, the equation of the bituminous coal price can be formulated as follows:

$$\begin{aligned}\text{Unit price} = {} & (2{,}500\alpha + 2{,}000(1-\alpha))(x_{1A} + x_{1B}) + (2{,}000\alpha + 1{,}500(1-\alpha))(x_{2A} + x_{2B}) \\ & + (2{,}000\alpha + 1{,}500(1-\alpha))(x_{3A} + x_{3B}) + (1{,}500\alpha + 1{,}000(1-\alpha))(x_{4A} + x_{4B}) \\ & + (2{,}000\alpha + 1{,}500(1-\alpha))(x_{5A} + x_{5B}) + (2{,}000\alpha + 1{,}500(1-\alpha))(x_{5A} + x_{5B}) \\ & + (2{,}500\alpha + 2{,}000(1-\alpha))(x_{7A} + x_{7B}) + (3{,}000\alpha + 2{,}500(1-\alpha))(x_{8A} + x_{8B}) \\ & + (2{,}500\alpha + 2{,}000(1-\alpha))(x_{9A} + x_{9B}) + (3{,}000\alpha + 2{,}500(1-\alpha))(x_{10A} + x_{10B}) \\ & + (2{,}500\alpha + 2{,}000(1-\alpha))(x_{11A} + x_{11B}) + (3{,}000\alpha + 2{,}500(1-\alpha))(x_{12A} + x_{12B}). \end{aligned} \quad (57)$$

Let binary variables y_{tA} and y_{tB} for t = 1,…, 12 be ordering variable, which is one when companies A and B receive orders, respectively, and 0 otherwise. The equation of the ordering cost can be formulated as follows:

$$\text{Ordering cost} = \sum_{t=1}^{12} 1{,}000{,}000 y_{tA} + \sum_{t=1}^{12} 1{,}500{,}000 y_{tB}. \quad (58)$$

Let decision variable I_t be the inventory level at the end of period t. The equation of the inventory holding cost can be formulated as follows:

$$\text{Inventory holding cost} = \sum_{t=1}^{12} 200 I_t. \quad (59)$$

Because the demand for bituminous coal for t = 1,…, 12 was based on the judgment of decision maker, it is a fuzzy demand. Therefore, there are 24 equivalent crisp inventory balance constraints of 12 periods, as follows:

$$x_{1A} + x_{1B} - I_1 \geq 10{,}000\alpha + 5{,}000(1-\alpha), \tag{60}$$

$$x_{1A} + x_{1B} - I_1 \leq 15{,}000\alpha + 20{,}000(1-\alpha), \tag{61}$$

$$I_1 + x_{2A} + x_{2B} - I_2 \geq 25{,}000\alpha + 20{,}000(1-\alpha), \tag{62}$$

$$I_1 + x_{2A} + x_{2B} - I_2 \leq 30{,}000\alpha + 35{,}000(1-\alpha), \tag{63}$$

$$I_2 + x_{3A} + x_{3B} - I_3 \geq 35{,}000\alpha + 30{,}000(1-\alpha), \tag{64}$$

$$I_2 + x_{3A} + x_{3B} - I_3 \leq 40{,}000\alpha + 45{,}000(1-\alpha), \tag{65}$$

$$I_3 + x_{4A} + x_{4B} - I_4 \geq 35{,}000\alpha + 30{,}000(1-\alpha), \tag{66}$$

$$I_3 + x_{4A} + x_{4B} - I_4 \leq 40{,}000\alpha + 45{,}000(1-\alpha), \tag{67}$$

$$I_4 + x_{5A} + x_{5B} - I_5 \geq 35{,}000\alpha + 30{,}000(1-\alpha), \tag{68}$$

$$I_4 + x_{5A} + x_{5B} - I_5 \leq 40{,}000\alpha + 45{,}000(1-\alpha), \tag{69}$$

$$I_5 + x_{6A} + x_{6B} - I_6 \geq 35{,}000\alpha + 30{,}000(1-\alpha), \tag{70}$$

$$I_5 + x_{6A} + x_{6B} - I_6 \leq 40{,}000\alpha + 45{,}000(1-\alpha), \tag{71}$$

$$I_6 + x_{7A} + x_{7B} - I_7 \geq 45{,}000\alpha + 40{,}000(1-\alpha), \tag{72}$$

$$I_6 + x_{7A} + x_{7B} - I_7 \leq 50{,}000\alpha + 55{,}000(1-\alpha), \tag{73}$$

$$I_7 + x_{8A} + x_{8B} - I_8 \geq 45{,}000\alpha + 40{,}000(1-\alpha), \tag{74}$$

$$I_7 + x_{8A} + x_{8B} - I_8 \leq 50{,}000\alpha + 55{,}000(1-\alpha), \tag{75}$$

$$I_8 + x_{9A} + x_{9B} - I_9 \geq 35{,}000\alpha + 30{,}000(1-\alpha), \tag{76}$$

$$I_8 + x_{9A} + x_{9B} - I_9 \leq 40{,}000\alpha + 45{,}000(1-\alpha), \tag{77}$$

$$I_9 + x_{10A} + x_{10B} - I_{10} \geq 25{,}000\alpha + 20{,}000(1-\alpha), \tag{78}$$

$$I_9 + x_{10A} + x_{10B} - I_{10} \leq 30{,}000\alpha + 35{,}000(1-\alpha), \tag{79}$$

$$I_{10} + x_{11A} + x_{11B} - I_{11} \geq 15{,}000, \quad (80)$$

$$I_{10} + x_{11A} + x_{11B} - I_{11} \leq 20{,}000\alpha + 25{,}000(1-\alpha), \quad (81)$$

$$I_{11} + x_{12A} + x_{12B} \geq 15{,}000, \quad (82)$$

$$I_{11} + x_{12A} + x_{12B} \leq 20{,}000\alpha + 25{,}000(1-\alpha). \quad (83)$$

Based on transportation capacity limitations, the maximum transportation capacity of companies A and B is 50,000 metric tons per period, the constraint for the control ordering variable can be formulated as follows:

$$50{,}000y_{tA} \geq x_{tA} \text{ and } 50{,}000y_{tB} \geq x_{tB} \text{ for t = 1,..., 12.} \quad (84)$$

Focusing on the inventory space limitations, the bituminous coal cannot be stored at a quantity greater than 60,000 metric tons. Thus the warehouse capacity constraints are added as follows:

$$I_{t-1} + x_{tA} + x_{tB} \leq 60{,}000 \text{ for t = 1,..., 12.} \quad (85)$$

The minimum total cost, binary variables, order quantity, and inventory level for each α-level set can found by solving MILP, min (57) + (58) + (59), subject to (60)-(85), where y_{tA} and $y_{tB} \in$ binary variables, x_{tA}, x_{tB}, and $I_t \geq 0$ for t = 1, ..., 12. The results at α = 0 and 1 are shown in Table 4.

Table 4: Inventory plan at α = 0 and 1.

Period	**Company**	**α = 0 and TC = 540,000,000**			**α = 1 and TC = 813,000,000**		
t		**y**	**x**	**I**	**Y**	**x**	**I**
1	A	1	5,000	0	1	10,000	0
	B	0	0		0	0	
2	A	1	20,000	0	1	25,000	0
	B	0	0		0	0	
3	A	1	30,000	0	1	35,000	0
	B	0	0		0	0	
4	A	1	50,000	30,000	1	50,000	25,000
	B	1	10,000		1	10,000	
5	A	0	0	0	1	10,000	0
	B	0	0		0	0	
6	A	1	50,000	30,000	1	50,000	25,000
	B	1	10,000		1	10,000	
7	A	1	30,000	20,000	1	35,000	15,000
	B	0	0		0	0	
8	A	1	20,000	0	1	30,000	0
	B	0	0		0	0	

9	A	1	50,000	20,000	1	50,000	25,000
	B	0	0		1	10,000	
10	A	0	0	0	0	0	0
	B	0	0		0	0	
11	A	1	30,000	15,000	1	30,000	15,000
	B	0	0		0	0	
12	A	0	0	0	0	0	0
	B	0	0		0	0	

If a decision maker wants to plan for the lowest total cost, the lowest of possible level ($\alpha = 0$) is chosen. The inventory plan orders 5,000, 20,000, and 30,000 metric tons of bituminous coal, which is transported by company A, in periods one, two, and three, respectively. To serve the demand of periods four and five, 60,000 metric tons must be refilled. Since the maximum transportation capacity of company A is less than 60,000 metric tons, an excess demand (10,000 metric tons) must be transported by company B. In period six, 60,000 metric tons of bituminous coal is ordered. An aggregate total of 30,000 metric tons, which is ordered in period seven, and 30,000 metric tons, which was transferred from period six, must be used to serve the demand of periods seven and eight. In period nine, 50,000 metric tons is ordered to cover periods nine and ten, and 30,000 metric tons is ordered in period eleven to cover the demand of the last two periods. The total cost is 540 million THB. On the other hand, when the highest possible level ($\alpha = 1$) is required, the total cost increases to 813 million THB. The inventory plan of this scenario orders 10,000, 25,000, and 35,000 metric tons in periods one, two, and three, respectively. To serve the demand of periods six, seven, and eight, 60,000 and 35,000 metric tons is ordered respectively, in periods six and seven. In period nine, 60,000 metric tons is ordered to cover periods nine and ten, and 30,000 metric tons is ordered in period eleven to cover the last two periods.

CONCLUSIONS

This paper used Possibility Approach to convert the fuzzy inventory model (F-USILSP) to an equivalent crisp inventory model (EC-USILSP). Consequently, the EC-USILSP can be solved by traditional mathematical programming methods. In addition, this EC-USILSP was adopted for inventory planning in the case study of inventory planning for bituminous coal with trapezoidal fuzzy demand and triangular fuzzy unit price in a power plant of a petrochemical company. The EC-USILSP is very flexible to solve problems, for example, before using EC-USILSP in the case study, the EC-USILSP could be modified to support additional restrictions on two issues; transportation capacity limitations and inventory space limitations. The results found higher possible levels are required, and the total cost will increase accordingly.

FUTURE STUDIES

In this article, SILSP with fuzzy parameters, which is the smallest problem, was selected as the sample to study. Future work could focus on, firstly, using other more sophisticated inventory models, such as a multiple item lot sizing problem in a single-stage and multiple-stage production; and secondly, a study of SILSP with several periods, where these problems would be more complex. Consequently, solving these problems requires a lot of time. Therefore, for future work, comparisons should be made between ‘optimization methods

and Meta Heuristics' and 'optimization methods or Meta Heuristics' to test which is more appropriate in these cases. Lastly, this article focuses only on inventory models with fuzzy parameters, but some parameters of inventory models may have variations in other characteristics, such as random variables or random fuzzy variables. Therefore, in future study, models should be developed to support other parameters.

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THE STUDY OF LOGISTIC OPERATION MODELS BETWEEN COMPANIES INSIDE AND OUTSIDE DOMESTIC AND FOREIGN INDUSTRIAL ZONES - A CASE STUDY OF SOLAR ENERGY INDUSTRY IN TAIWAN

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ABSTRACT

Facing an atmosphere of the fierce global business competitiveness increasingly, if a company wants to employ the traditional manufacturing improvement method to significantly raise the business survival ability, it cannot achieve the objective. As a result, a company needs to review it's as-is logistics business and operation model from a whole viewpoint to develop a feasible innovative to-be logistics model between companies inside and outside domestic and foreign industrial zones. This research adopts the solar energy industry in Taiwan as an example to profoundly investigate the as-is logistics operation models between companies inside and outside industrial zones, including logistics business models, logistics operation models, inventory management and so on. At the same time, this research points out the shortcomings and provides the concrete and substantial suggestions of the as-is models for the solar energy industry. After understanding the status of integrating manufacturing between companies inside and outside domestic and foreign industrial zones, this study finds the critical success factors of integrating manufacturing inside and outside industrial zones for the solar energy industry. Then this study proposes the feasible models of integrating manufacturing inside and outside industrial zones and executes the difference analysis between the as-is model and the to-be model. After creating the business models of integrating manufacturing inside and outside industrial zones, we undertake the detail logistic operation model of integrating manufacturing inside and outside industrial zones. Finally, this research presents the concrete and valuable suggestions for implementing the logistics operation models of integrating manufacturing.

Keywords: Inside and outside domestic and foreign industrial zones, Logistics business model, Logistic operation model, The solar energy industry.

INTRODUCTION

Today enterprises have focused on reducing manufacturing costs by decreasing the inputs of human and manufacturing resources for achieving the aim of lean production. However, facing an atmosphere of the fierce global business competitiveness, it reaches the limits of this way to improve competitiveness of enterprises by using the global division of work and a high-quality production system to reduce production costs and shorten delivery. Furthermore, the rise of the concept of manufacturing services drives the current manufacturing to rethink whether as-is logistics operation models are able to quickly respond customer demands in order to grip the pulse of market demand. Therefore, enterprises must escape the operation of the current thinking to break the existing stereotype of the corporate business model in order to survive in the competitive industry environment. In this point of view, enterprises must develop innovative integrated logistics business model from the optimization of a entire system and considering different industry clusters and industrial properties in order to enhance their entire operational efficiency, enable them to shorten the delivery time, reduce costs and improve customer service quality vision.

THE INTEGRATION PROCESS AND THE STATUS OF DOMESTIC INDUSTRIAL PARK INSIDE AND OUTSIDE

The overview of solar energy industry

Looking at the current energy, using of new solar and wind power is the fastest growing and popular. Since 1997, the solar energy industry market has 33% growth per year [2]. So we know wind and solar at this stage will be the most promising of the green energy. Germany, Japan and Spain have better development in solar energy industry, such as promoting policies and larger solar market demand [1, 5]. China also have been pushed solar energy industry hardly in recent years [3]. Unfortunately, the price of international module continues falling, and the span of expected fall is 5% [4]. It means that manufacturing margins had squeezed, we must improve the logistics model to execute the cost down strategy.

However, solar power without fuel and waste, each unit of electricity can reduce carbon dioxide emissions 0.581 g, and the sun will light at least 50 billion years, solar power is an best options to substitute traditional fossil fuel.

Because a wide range of solar applications, this research takes the mono and poly-silicon solar energy industry as an example to profoundly investigate logistic operation models between companies inside and outside domestic and foreign industrial zones.

The as-is business models of integrated process between companies inside and outside domestic and foreign industrial zones

Because the differences among the specifications of solar applications are very small, the price is a critical factor for competing in the solar energy market. To ensure that the downstream solar energy manufacturers can obtain enough components and maintain price competitiveness, some solar energy manufacturers in Taiwan have begun toward the

direction of vertical integration. For example, Tatung Company has established an initial vertical integration business model for the solar energy industry.

This study collects the typical as-is business models of the solar energy industry; which can be divided into four models as follows:

a) *Partial vertical integration business model for the solar energy industry chain:*

A company has abundant capital to vertically integrate the up-stream, middle-stream and/or down-stream solar energy supply chain through transferring investment to set up subsidiaries or stock ownership means. For example, Tatung invested Sanchih Semiconductor Company, and then Sanchih Semiconductor Company invested to establish Green Energy Technology Company. Green Energy Technology Company is responsible for silicon ingots and silicon wafer manufacturing, but also engaged in the production of solar cells and modules. In the downstream of the solar energy supply chain, Tatung Company adopts the parallel strategy of OBM (Original Brand Manufacturing) and OEM (Original Equipment Manufacturing).

b) *The horizontal integration business model for homogeneous companies in the solar energy industry chain:*

For example, AUO Company aggressively start global deployment for solar cell modules including Taichung in Taiwan, Tianjin in China and Czech Republic and other places to set up factories in order to develop China, European and Asian markets. Since Europe is the largest solar energy market in the world, AUO applied the homogeneous horizontal integration business model to develop oversea solar module plants to amplify the market share in Europe.

c) *The horizontal integration business model for heterogeneous companies in the solar energy industry chain:*

Formosa Plastics Group utilizes its strong financial foundation and excellent R&D capabilities in the plastics industry to develop key materials of the solar energy industry chain. Development of these key materials is the high threshold, but the profit is abundant. For example, Formosa Energy & Material Technology Company is responsible for the production of lithium-iron battery material In addition, Formosa Plastics Company produces EVA film and Silane. AUO and component supplier of system integration perform the heterogeneous horizontal integration to provide final solar energy application solutions.

d) *Focusing on specific areas in the solar energy industry chain:*

Fuju Solar Energy Company in Taiwan will devote itself to poly-silicon production. The company is located in Pingtung Export Processing Zone in Taiwan, which meets market demands of silicon ingot and silicon wafer manufacturers in Tainan Science Park, Luchu Science Park, Hsinchu Science Park and Taoyuan area. Danone Technology Company focuses on silicon ingot and silicon wafer production and then sell solar silicon wafers to domestic and foreign solar cell manufacturers. Ritek Company at the Hsinchu Industrial Park in the

middle stream of the solar energy industry chain is responsible for solar module manufacturing.

The integrated process logistics model between companies inside and outside domestic and foreign industrial zones

Companies in the upstream solar energy industry chain adopt make-to-stock (MTS) model. First, manufacturers develop production plans based on sales forecasts. Then, the manufacturers begin preparing the required materials based on material requirement planning. Nowadays the manufacturers of poly-silicon materials in Taiwan have not begun mass production. Thus, the solar chip manufacturers in Taiwan purchase the required poly-silicon materials from foreign suppliers. Foreign suppliers deliver poly-silicon materials to bonded warehouses. When manufacturers start processing, they remove the required materials from the bonded warehouse. After finishing the manufacturing, semi-finished products will be placed in the warehouse. If companies receive domestic orders, the third party logistics service providers with a long term cooperation relationship deliver these semi-finished products. If the orders come from foreign customers, the customs brokers deal with customs operations, and then send the silicon wafer to foreign manufacturers by sea transportation. Figure 1 shows the logistics business model of the upstream solar energy industry chain.

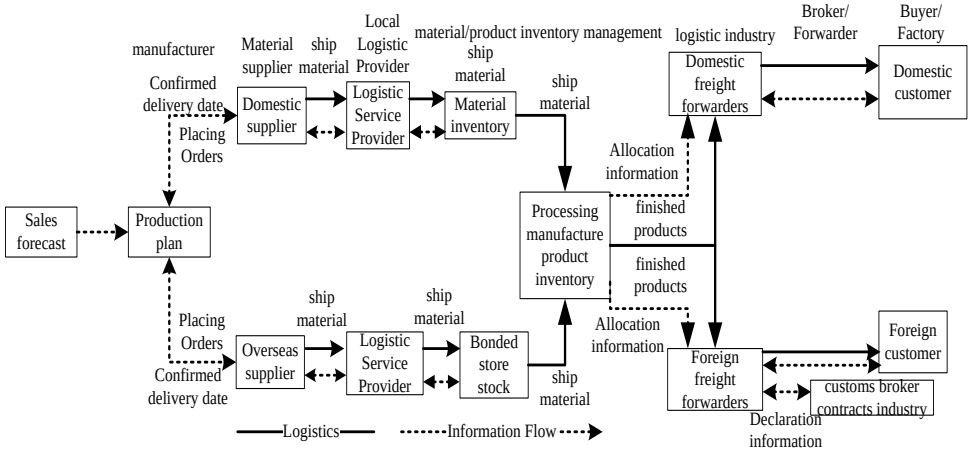

Figure 1: The logistics business model of the upstream solar energy industry chain.

With respect to the solar cell logistics, solar cell manufacturers purchase poly-silicon material from the suppliers in Europe, the United States and other countries. The small amount of solar silicon wafers come from the domestic manufacturers. The purchase of raw materials from foreign suppliers adopts the bonded way. Most solar cell customers come from foreign area. Because the salt could erode the solar cells, the volume of solar cells is small and sea transportation spends a lot of time, the majority of solar cells are delivered by air transport. When the customers abroad receive solar cells, they send confirmation to the solar cell manufacturers, and then complete the overseas orders. The domestic orders for solar cells are implemented by land transportation. Similarly, when domestic customers receive the goods, they will send a confirmation to the solar cell manufacturers to complete domestic orders.

Figure 2 and Figure 3 show the as-is models between companies inside and outside domestic and foreign industries zones for solar cell modules and solar energy application. As solar cell modules and solar application belong to the build-to-order (BTO) business model. When the companies get orders, they check whether the standard parts are enough. If inventory is not enough, then they start purchasing standard parts. Meanwhile, they also begin purchasing required non-standard components. However, owing to the considerations of quality and bond, they import components from Europe, the United States, South Korea and Japan. Figure 3 shows the purchasing logistics operation model of the solar cell modules and solar applications between companies outside and inside industrial zones.

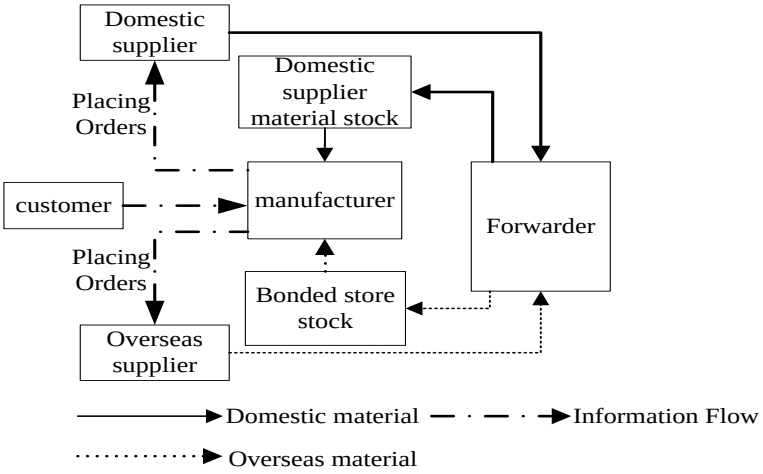

Figure 2: The solar cell modules and solar energy industry applications outside and inside integration of processing the feed mode of operation.

With regard to delivery logistics, first, domestic or foreign companies release orders to headquarters. The order information is passed to the manufacturing sector. When the manufacturing sector receives a manufacturing order, it starts picking and processing operations. After finishing the manufacturing process, finished products are briefly placed in storage area of finished goods. Finally, the operations department contacts with the forwarders immediately. If the product is exported to foreign manufacturers, it will inform the customs, and finished goods are to the seaport. On the other hand, if the products are delivered to domestic customers, it will transport directly to the destination by freight forwarder.

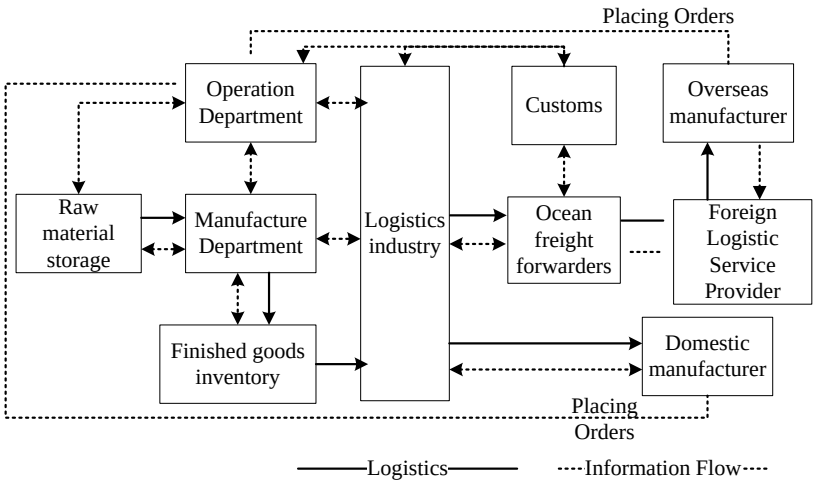

Figure 3: Solar application of industrial plant inside and outside the system integration process of the logistic model

The defects in the current situation and improvement recommendations for integrated process between companies inside and outside industrial zones

Nowadays, poly-silicon materials factories have not begun mass production yet. Solar silicon wafer manufacturers must rely on foreign imports, including the United States, Germany, Japan and Korea. Since the poly-silicon materials will spend a lot of time in set transport, the solar silicon wafer manufacturers need to prepare the high safe stock levels that lead to the increase of inventory cost. Owing to the manufacturing pollution, this research recommends poly-silicon material factory should be built at a lower population density like Pingtung Export Processing Zone. In addition, it can meet the requirement of the poly-silicon materials at the Tainan Science Park and Kaohsiung Science Park.

In regard to the middle-stream solar energy industry, the specification difference of solar cells is very small. Hence, most companies adopt make-to-stock (MTS) business model. In the down-stream solar energy industry, manufacturers adopt the build-to-order business model, so they don't storage finished product inventory. Because domestic solar energy chip manufacturers' capacity cannot meet the requirements of solar energy cell manufacturers, the main sources of solar chips come from foreign solar energy chip manufacturers. In respect of solar energy modules, the main components including solar cells, EVA films, backboards and low-iron glass also depend on foreign imports. Only the small portion of the purchase is by domestic manufacturers. Owing to the recent policy of the German government, the orders of solar application are significantly increasing to lead to shortages of materials and components. Therefore, foreign suppliers of raw materials and components have great influence on the solar energy industry in Taiwan. Furthermore, the down-stream solar energy industry companies face the delivery problem. Because the volume of a solar cell module is large, they are easy to injure in transportation process. Therefore, the solar cell module plants are suitable for the establishment of production lines near the market. As the domestic market of solar energy applications is smaller, solar cells and modules are export. This research suggests that Taiwan's solar cell and module manufacturers can use their superior production technology to cooperate with foreign factories to obtain a large solar energy power plant projects.

The above description shows the Taiwan's solar energy companies highly depend on foreign raw materials and components, regardless of up-stream, middle-stream or down-stream solar energy industry. Figure 5 shows which the supply relationships should be enhanced. In order to improve the competitiveness of Taiwan's solar energy industry, the raw material and component suppliers in the upstream solar energy chain need to provide the low price materials and components under the same quality condition to downstream manufacturers. The delivery time and production costs of the down-stream solar energy companies must be more competitive, and can be able to the effective helm of the up-stream material supply. In addition, the raw materials are imported through the Port of Keelung. Under the consideration of plant locations, if we can change to other ports such as the ports of Taichung or Kaohsiung to unload raw materials and components, we can reduce the transportation cost.

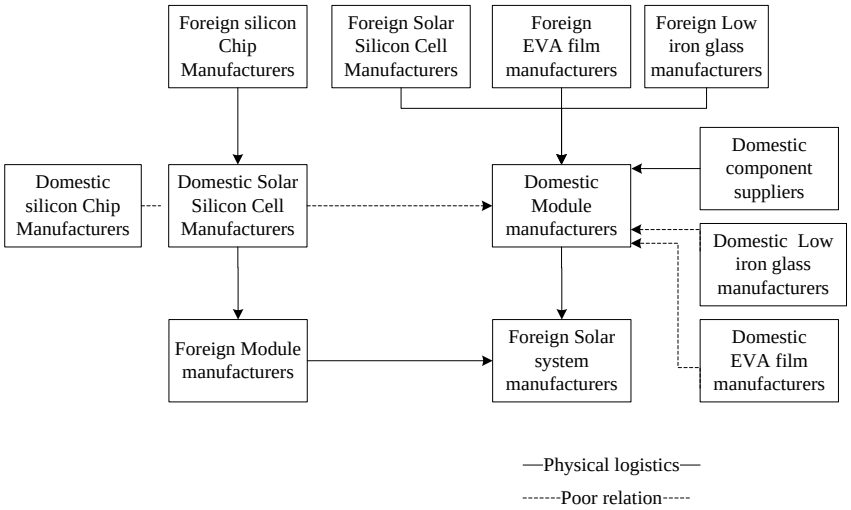

Figure 4: Shows strengthen the relationship between each other's supply diagram for current solar energy industry supply chain.

In addition, the manufacturing of both solar cells and modules in Taiwan has not reach economies of scale. Hence, compared with other international solar energy manufacturers, production cost in Taiwan's companies is still higher.

THE ANALYSIS OF THE FEASIBLE MODELS OF INTEGRATED PROCESS BETWEEN COMPANIES INSIDE AND OUTSIDE DOMESTIC AND FOREIGN INDUSTRIAL ZONES

This section depicts the feasible models of integrated process between companies inside and outside domestic and foreign industrial zones for solar energy industry. The details of integrated process are described in the following sub-sections.

The key factors for implementing the integrated processes between inside and outside solar industrial zones

The key factors to promote the integrated processes between inside and outside industrial zones for the solar energy industry are described as follow:

a) Because the sources of the poly-silicon materials and solar energy cells rely on foreign imports in Taiwan, the transportation cost and inventory cost are significantly increases. Hence, Taiwan's solar energy manufacturers should establish a complete the supply chain for the solar energy industry.

b) The solar manufacturing companies in Taiwan are distribured, it should integrate up-stream, middle-stream, and down-stream companies to become a regional industry cluster.

c) Because the market of the solar energy industry is very small in Taiwan, the solar energy industry belongs the export-oriented industry. The location of the manufacturers for the solar energy factories should is near the Free Trade Zones to reduce the cost and the time of land transportant.

d) Building solar plants in the Export Processing Zone and Free Trade Zone can reduce customs duties, commodity taxes, and operating costs significantly.

e) Because the solar cell modules are big in size, we suggest that solar module factories should be set up in the Free Trade Zones. The solar module factories can be easy to import needed components and export the solar energy modules.

f) If the solar energy industry can establish factories in the neighboring zone, it will be easy to implement VMI approach to decrease transportation costs, inventory costs, safety stock, and improve the efficiency of logistics operations.

The feasible model of integrated processes between inside and outside solar energy industrial zones

For the current status of the solar energy industry, this research proposes the feasible model and related regional planning to enhance the logistics efficiency of the solar energy industry.

The feasible model

So far, the solar energy companies do not completely integrate its supply chain throughout up-stream, middle-stream, and down-stream. Especially, the poly-silicon materials of the up-stream all rely on the foreign manufacturers. The domestic solar energy industry can't control the supply of raw materials. Meanwhile, the other critical materials, such as solar silicon wafers and solar cells, EVA film, need to rely on imports, so that it can't meet demand for order in the rush season. Besides, the solar energy industry chain has not yet formed a complete industry clusters and the solar energy manufacturers in Taiwan is too distributed. Owing to these causes, the solar energy industry in Taiwan must prepare high safety stocks. Hence, poly-silicon material manufacturers should be added and supply the domestic manufacturers so as to reduce the safety stock in the solar energy industry.

As the factors mentioned above, the operation cost in solar energy industry is increased significantly. In addition, to face the competition from China, the solar energy manufacturers in Taiwan can't adopt the low-cost competitive strategy. Therefore, Taiwan solar energy module companies need to be transformed into build-to-order business model and provide solar energy modules with technology aesthetics to significantly increase the value-added of products.

Location planning

Figure 5 shows the feasible model of the inside and outside domestic and foreign industrial zones for the solar energy industry. Because a solar energy industry needs vast land, and the Export Processing Zones and the Free Trade Zone in the south Taiwan have lower occupancy rate, land of the south Taiwan can satisfy the requirement of the solar energy industry chain. The up-stream solar energy industry with a lot of pollution, so we suggest poly-silicon plants materials and silicon wafer plants should be located in a lower population area such as Pingtung Export Processing Zone.

For the up-stream part, the Pingtung Export Processing Zone is 25 km away from the Kaohsiung Port and Kaohsiung International Airport. The silicon can be transported to the Pingtung Export Processing Zone from foreign mining areas. After the silicon ore is being processed to become poly-silicon materials, they can provide the poly-silicon materials to solar silicon wafer plants inside the industrial zone. The production of silicon wafers can conveniently meet the demands of solar cell factories in Kaohsiung Export Processing Zone.

For the middle-stream part, the solar cell plants are close to the Kaohsiung Free Trade Zone, they can use the convenient land, sea and air transport infrastructure to delivery products rapidly to domestic and foreign customers. Because of small size and light weight, the solar cell can be transported rapidly by air transportation.

For the part of down-stream, the surrounding materials of solar energy modules can be obtained from the Taichung Precision Machinery Park. Owing to the bulky solar energy modules, they may easily lead to damage in the transport process. Therefore, we suggest that solar energy module plant can be established in the Kaohsiung Free Trade Zone, and delivers their products directly to solar energy system manufacturers in foreign industrial areas by sea transport. The factories in Kaohsiung Free Trade Zone can obtain tax free, when they procure materials and components from tax districts in Taiwan or foreign countries.

In addition, the major markets of the solar energy industry are EU and USA. If the solar energy modules are shipped by sea transport to EU and USA, it would waste a lot of time and is hard to immediately response the customers' requirements. For this reason, domestic enterprises can build solar energy module plant at overseas to satisfy requirements of nearby markets. The feasible model proposed in this paper utilizes the convenient services provided by customs at the Export Processing Zone and the Free Trade Zone. In addition, the feasible model integrates land, sea and air transportation for importing raw materials and components, and exporting products. Hence, it will significantly raise the competitiveness of Taiwan's solar energy industry.

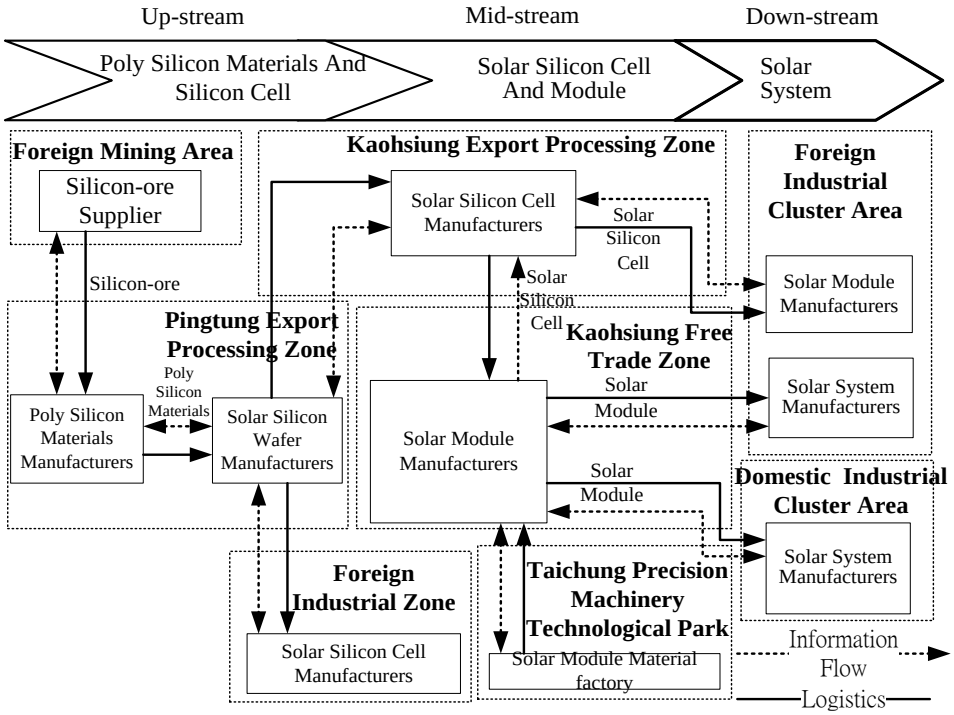

Figure 5: The feasible model of integrated processes between inside and outside domestic and foreign industrial zones for the solar energy industry in Taiwan.

Evaluation of the feasible model of integrated processes between inside and outside domestic and foreign industrial zones for the solar energy industry

The section elaborates the differences of the as-is and the to-be models as follows.

a) Industry cluster

In the as-is model, the members of solar energy industry chain are distributed in the north, central, and southern Taiwan. In the To-Be model, the companies gather in the southern industrial zones to become a domestic solar energy industry cluster.

b) Transport distance for semi-finished and finished products

In the as-is model, the members of the solar energy industry chain locate at the northern, central, and southern industrial areas in Taiwan, the semi-finished and finished products need the longer transport distances. In the to-be model, the members of industrial chain gather in the southern industrial zones to form the whole industry chain so as to shorten the delivery distances of semi-finished and finished products effectively.

c) Transportation cost

In the as-is model, because the providers for components of solar energy modules are not adjacent to the solar module plants, transportation costs are being raised significantly. In the to-be model, the transportation distance can be shortened through location planning because the solar energy module plants are located in the Free Trade Zone, and the suppliers of the solar energy modules are near the Free Trade Zone.

d) Global layout

In the as-is model, solar energy plants are located in Taiwan. Solar energy companies have not formed a global layout yet. For this reason, we suggest solar module plants should be adjacent to the nearby U.S. and Europe markets to understand and satisfy customer needs.

e) Import and export customs procedures

In the as-is model, because the manufacturers of solar energy industry chain are distributed in the domestic industrial zones, it is more complicated in the customs operations. In the to-be model, we suggest that the solar energy plants can be set in the Kaohsiung Free Trade Zone, the Pingtung Export Processing Zone and the Kaohsiung Export Processing Zone, to obtain convenient customs operations.

f) Probability of meeting the deadline

In the as-is model, the solar energy industry only has partial vertically integrated. At the same time, the critical raw materials may be shortage. Hence, these factors decrease the probability of meeting the deadline. In the to-be model, the solar energy industry has integrated completely, and can control critical raw materials. Hence, the to-be model can decrease the chance of shortage to increase the probability of meeting the deadline.

g) Vertical integration

In the as-is model, we lack the up-stream poly-silicon material manufacturers. In the to-be model, we suggest that the up-stream poly-silicon material manufacturers can be established in the Pingtung Export Processing Zone to form completely vertical integration.

h) Product Type

The solar energy companies just focus on standardized homogeneous products in the as-is model. However, this research suggests these companies should provide the solar energy products of customization and high efficiency conversion.

i) Safety stock

Because the as-is model lacks the up-stream poly-silicon material companies, it is hard to control the key raw materials. Hence, many companies keep higher safety stock. In the to-be model, the safety stock of the poly-silicon materials is reduced.

j) Inventory cost

Because of safety stock level is reduced in the to-be model, the solar energy companies can decrease the inventory cost.

k) Acquisition of key materials

In the as-is model, companies may lack poly-silicon materials. However, in the to-be model, the solar energy industry companies can effectively control the sources of poly-silicon materials.

CONCLUSION

According to the investigation of this research, original materials and major parts and components of Taiwan's solar energy industry depend on foreign import, especially poly-silicon materials. If the companies cannot ensure stable supplies of materials and components, they may face the shortage problems that can lead to interrupt the production line. Meanwhile, because the major suppliers of poly-silicon materials are EU & USA now, it takes a long purchasing time. Owing to fewer solar chip manufacturers in Taiwan, the capacity of solar chips cannot satisfy the demand of Taiwan's solar cell manufacturers. Therefore, solar cell manufacturers almost import solar chips. Concerning the solar cell modules, the major components including solar cells, EVA films, background boards, and low-iron tempered glass come from foreign manufacturers. The establishment of the solar energy supply chain is not complete yet. Hence, Taiwan's government should create the related laws to assist the sound development of the solar energy industry. Because the biggest solar energy market product is EU, Taiwan's solar energy companies should establish the solar energy module and system integration factories for reducing transportation cost and assuring quality.

In addition, by profoundly understanding the whole structure, the present situation, and the characteristics of the solar energy industry, this research finds the key success factors of integrated process between companies inside and outside industry zones for the solar energy industry, and then develops the feasible innovative to-be business model of solar energy industry. Because the solar energy industry needs a large land, this research suggests to integrate the neighboring Pingtung Export Processing Zone, Kaohsiung Export Processing Zone and Kaohsiung Free Trade Zone to built a integrated process business model between companies inside and outside industrial zones. At the same time, this research develops a detail logistic operation model of the solar energy industry based on the above-mentioned innovative business model.

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D1 – Organizational-management perspectives

D1.1 **Evolution of EHSQ management systems towards integrated management systems**
Osmo Kauppila

D1.2 **Using the BCFI method to improve idea management**
Arto Jyrälä

D1.3 **A case study on Chinese failure in ERP implementation**
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EVOLUTION OF EHSQ MANAGEMENT SYSTEMS TOWARDS INTEGRATED MANAGEMENT SYSTEMS

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ABSTRACT

Organisations, especially in the business sector, are in constant demand to improve their operations, competitiveness and efficiency. Systems thinking is one of the ways to meet this demand at least in larger organisations. Standard-based management systems related to areas such as environmental management, health & safety and quality have become important organisational building blocks. It can be argued that in order to avoid harm caused by overlapping structures and operations these systems should be integrated.

In this article, the evolution and effective integration of EHSQ (Environment, Health, Safety and Quality) management in a business organisation are studied. The evolutional development paths of environmental management, health and safety management and quality management are studied. A comparison between the development paths is made to find similarities and differences in the development of these management systems.

To understand how EHSQ integration should take place in an organisation, elements of an integrated management system are presented. The benefits and challenges arising from the implementation of an IMS are also studied. Together the study on EHSQ development paths and integrated management systems present a view on effective EHSQ integration.

Keywords: integrated management systems, IMS, environmental management, health and safety management, quality management

INTRODUCTION

The constant need of organisations to continuously develop their operations, competitiveness and efficiency has resulted in the need for system thinking. Fulfilling the diverse requirements of various stakeholders requires different approaches. The constant increase of these requirements has highlighted the need for a systematic approach to handle them. This has led to a dramatic increase in the development of management systems (MS). MSs help control systems and provide systematic ways to standardize functions. (Asif et al., 2010a) Different management systems offer an operating framework and procedure and simultaneously support continuous improvement. (Voutilainen et al., 2001)

These systems often share resources, processes and stakeholders, suggesting that integrating them could be beneficial. Zutshi and Sohal (2005) even state that "the integration of systems/standards is one of the major strategies for ensuring survival and savings (time, cost, resources) for the organizations in the twenty-first century". Integrated management systems (IMS) are being implemented at an exceeding pace, the most important motivations according Zeng et al. (2010) are satisfying customer requirements, responding to government appeal and remaining competitive. The most commonly integrated management systems are quality, environmental and occupational health and safety standards. They are often based on widely used standards such as ISO 9001, ISO 14001 and OHSAS 18001 that include common characteristics and starting points, which make them relatively easy to integrate. (Zeng et al., 2007; Jørgensen et al., 2006; Wilkinson and Dale 1999)

Along with business interest in management systems and their integration, research interest in them has increased dramatically during the last decade. This study aims to contribute in the field by summarizing the historical development of the aforementioned areas of environmental, health & safety and quality management (EHSQ) and looking at them in the context of integrated management systems. The research has been broken down into three research questions:

RQ1: What have been the development paths of different areas of EHSQ management?
RQ2: What elements does an integrated management system include and how can the efficiency of an IMS be assessed?
RQ3: What are the main benefits and challenges of IMS implementation on organizational success?

This study summarizes and continues the dissertation work of one of the authors (Tervonen, 2010). The research questions are answered through a literature review. The research results aim to present the historical development leading to the rise of integrated management systems, the current view on how IMS integration should take place and what benefits and challenges lie in the integration The structure of the research is demonstrated below in Figure 1.

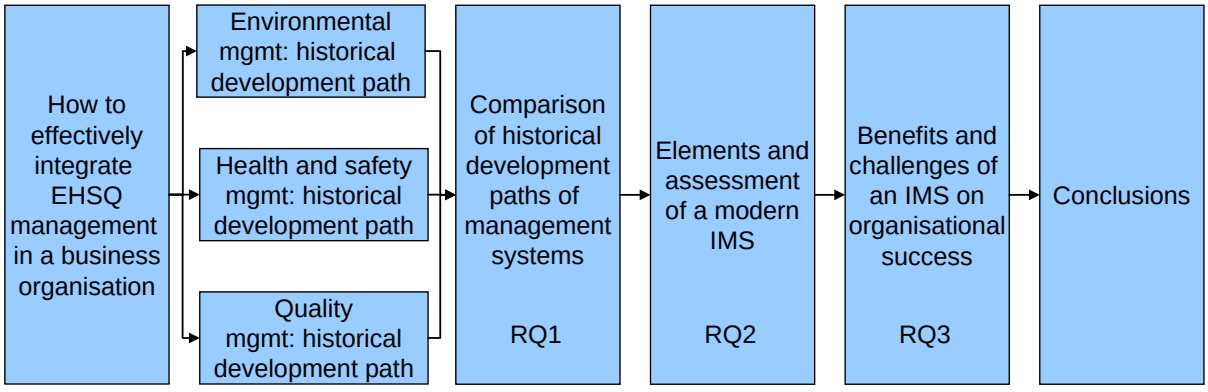

Figure 1: The outline of the study.

DEVELOPMENT PATHS OF EHSQ MANAGEMENT SYSTEMS

The current situation in different areas of EHSQ management becomes clearer through an understanding of historical development. The logic behind existing policies and the direction of development stems from the past. By recognizing the path leading to the current situation, it is easier to analyse the present and also future trends of development. The analysis results can be compared to the development and situation of an organization's EHSQ management to aid development.

Environmental management

Environmental issues raised public interest in the 1960's in a rather sudden and dramatic way. Rachel Carlson's book Silent Spring (1962) can be considered an important opening statement of the environmental discussion (Kallio, 2001). This started the process leading to the birth of environmental management (EM) in the 1970s. Before this, emission restrictions and environmental regulations were rather rudimentary in many fields, and pollution was practically considered a free commodity by companies.

A heated debate on the pros and cons of economic growth began in the beginning of the 1970's. An important initiator of the debate was the UN's first Conference on the Human Nature in Stockholm in 1972 and the Limits to Growth report of the Club of Rome published the same year. The oil crises in 1973 and 1979 resulted in an increasing concern for the sufficiency of natural resources. The environmental policy sector was created in the 1970's. Traditional environmental management, the first stage of environmental management, was a period of reluctant adaptation. Environmental factors were seen as restrictions on operations to which one had to adapt to when faced with external enforcement. The companies had to start adapting their operations to new regulations. A majority of multinational companies created their own environmental policies. Only a few companies included the goal of voluntarily exceeding the minimum levels required by legislation in their policies (Kallio, 2001).

The second stage of environmental management – passive appraisal – commenced in the mid-1980's when it was realised that no organisation could succeed in the long run if their operations were in major conflict with the requirements and values of the surrounding society. This stage was characterised by companies re-evaluating their approach to environmental issues and the recognition of their strategic potential. This stage can be considered the starting point of modern environmental management. (Kallio, 2001; Petulla, 1987)

Ministries of the Environment were established in the 1980's. Environmental activism found new forms as a result of internationalisation and professionalization and several environmental organisations were created. As a result of massive environmental accidents and an increasing concern for the environment in the 1980's new, increasingly strict environmental legislation and regulations were created. Growing demands of consumers, corporate clients, and investors also emerged as new factors. Previously passive companies had to readjust their attitude towards environmental issues. As a result environmental departments and monitoring systems were created and major companies even employed

environmental managers. The concept of sustainable development was created during the 1980s. (Kallio, 2001).

Only a few companies had reached the level of innovative EM by the beginning of the 1990's. The 1992 UN Rio de Janeiro conference can be considered as the highlight of the decade from an environmental viewpoint. The conference led to the creation of the international Climate Change Convention (Kallio, 2001). However, the green transformation of companies was only in a very early stage and no significant actions were made to reduce emissions or other environmental impacts. Procedures and practices only started to change towards the end of the 1990's as environmental management tools became more common through the introduction of ISO 14001.

In the 2000's, modern environmental management is still the most dominant trend. The field of environmental management has evolved from a mere reliance on linear stage models to more elaborate considerations of the determinants and components of management and performance. An increasing number of companies are adopting the practices of environmental management. In addition, the strategic opportunities of environmental management are becoming prominent (Kolk and Mauser, 2002). Eco-efficiency has become an important issue for companies. Pressure from legislation and markets, as well as globalisation, increasingly impact the environmental aspects of business. Climate change emerged as the most important environmental issue in the 2000's, resulting in emission trading becoming a significant EM factor. (Heiskanen, 2004).

Table 1 synthesizes the development path from the viewpoints of the (Finnish) state, companies, the civic society and nature. The focus of EM has been changing from traditional EM guided by laws and regulations to the more proactive modern EM. Environmental management has become a potential source of competitive advantage.

Table 1: Illustration of state, civic society and companies' relationship to environment (Kallio, 2001).

	State	Companies	Civic society	Nature
1960	Supporting industry Industry thinking	Investing in basic industries Territory thinking	Grass roots civic movements Global thinking	Water spoilage
1970	Water and toxic laws Sanction thinking	Concern for natural resources Expansion thinking	Environmental movement organisations, Life style thinking	Air pollution
1980	Nationalization of environmental protection Control thinking	Green transformation of enterprises Expansion thinking	Institutionalization of nature protection Consumer thinking	Tshernobyl Acid rain Exxon Valdes
1990	Sustainable Development Program thinking	Commercialization of environment Specialized thinking	Emphasizing consumer choices Eco-thinking	Climate change Ozone layer Logging of forests
2000	Implementation of programs Policy of natural resource	Increasing competition Survival strategies	Pattern of differentiation Differentiation of consumption	Climate change

Integration has developed EM closer to risk management and integrated process based management. Johnson and Walck (2004) suggest that the optimal way to achieve sustainability is to integrate sustainability values into the business values and strategies of a company. In recent years, business level organisations have been able to gain a competitive edge through the proactive utilisation of EM issues. Lanoie, Laplante and Roy (1998) found that capital markets react to the release of negative information and that large polluters are affected more significantly by such releases than smaller polluters. Niskala (1997) suggests that in order to support eco-competitiveness, the management of environmental issues must be holistic and consider all the operations of an organisation.

Health and safety management

The extent of health and safety (HS) management can be classified into three categories: person, machine or equipment and organisation levels (Figure 2). The classification also describes the increase of complexity when moving from a person level to machine and organizational levels. (Reason, 1997)

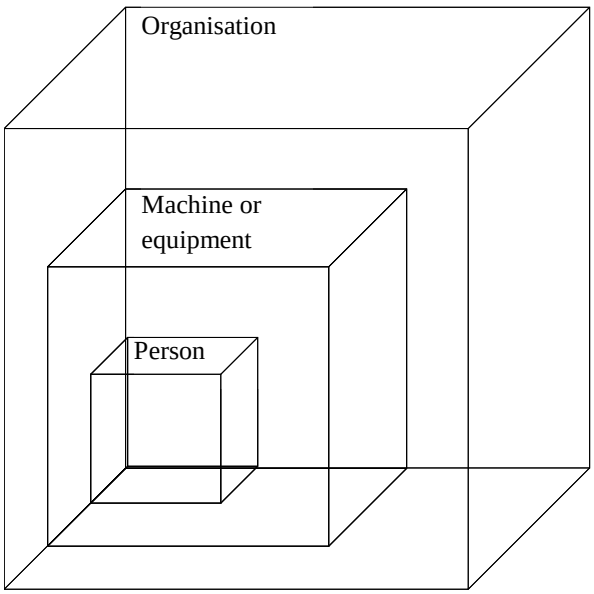

Figure 2: Classification of the scope and development level of health and safety management.

On the “person” level, the focus on observation is on whether the worker works in a safe manner or not. Failures are attributed to human actions, such as lack of motivation, lapses of memory or carelessness. Performance is often measured by means of accident frequency, and the safety organisation of work plays a key role. On the “machine or equipment” level failures are attributed to the interaction between humans and machines. Safety actions are characterised by risk analyses and the assessment of environmental impacts on human beings. According to the third category, a human error is a result of an identifiable cause in the system. This mode of thinking has common points with quality management, emphasising proactivity and continuous improvement. (Reason, 1997) The improvement of both quality and safety will result in a higher level of risk prevention, which creates the basis for an integrated management model. Herrero et al. (2002) suggest that the concepts of TQM can be applied to the practices of health and safety management.

The operating cultures in different sectors of health and safety management differ considerably, and legislation usually only governs the regulations of a single sector. This sets challenges for successful implementation. A view on the development path of legislation-making concerning different fields of HS management in Finland is presented in Table 2. It also reflects the general development of the content of HS management.

Table 2: The development path of legislation concerning different areas of HS management in Finland (Tervonen et al., 2009b).

Sectors	1930	1940	1950	1960	1970	1980	1990	2000
Personnel security*								x
Rescue operations	x		x	x	x		xx	xx
Safety against crime**								x
Information security							x	xxxx
Safety of buildings and premises						x		xx
Safety of production and operations			x	xx	xxx		xxxxx	xx
Occupational health and safety	x	x	x		xxxxx			xx
Safety of non-domestic operations***								x
Readiness planning				x	x		xx	x
Environmental safety					x	x	xx	xx

x = commencement and reform level of legislation
* is connected to occupational health and safety and information security
** is connected to general crime legislation
*** is connected to personnel security, safety against crime, rescue operations and safety of production and operations

Following regulations has meant passive organisational development- defined outside the organisation by the regulators and government. Only in recent years the development has took on a more active approach. Individual methods beyond authority regulations can lead to sustainable competitive advantages. These methods may overlap and support each others, and strict running after the regulations might result in unnecessary double work.

Several different parties participate in the HS operations of large companies, and the different sectors of health and safety, as well as risk assessment, is often treated in a number of places around the organisation. In addition, risk assessment often addresses risks from the viewpoint of only one sector of, and the results of a single assessment do not reach the different representatives of the safety organisation. Evaluation of the different sectors of may lead to a situation in which improvements are only made in the sector evaluated at a given time. The impacts of the measure on the overall level of health and safety of the organisation are not taken into consideration. In terms of overall performance, the best solutions can be found by assessing the impacts of an improvement on all sectors. The goal is to avoid overlapping work in risk assessment in different sectors of and waste of resources. More holistic management of health and safety issues can be achieved by increasing co-operation between people responsible for different sectors of safety. (Hill & Smith, 1995; Lanne & Tytykoski, 2004)

The first health and safety management system applications were based on the Occupational Health and Safety Management System (BS 8800) and the Dutch Safety Checklist for Contractors (SCC) standard. BS 8800 was replaced with the international OHSAS specifications in 2000. The Occupational Health and Safety Assessment Series specifications OHSAS 18001 supports the assessment and certification of the management systems of organisations. In addition, the International Labour Organisation (ILO) has published instructions on occupational health and safety systems (ILO-OHS 2001). The International Safety Rating System (ISRS 1996) is a method for auditing safety management procedures and the functionality of the systems. The safety practices self-assessment model

complements the European Quality Award model by taking the occupational health and safety issues into consideration in a more comprehensive manner. (Levä, 2003) Integration of e.g. occupational health and safety matters into environmental management systems can bring many benefits to industrial companies. They can avoid duplicated measures and find optimal solutions, because the principles of prevention are similar in environmental protection and health and safety management (Honkasalo, 2000).

Quality management

Total quality management is a philosophical entity of the concept of management and a compilation of quality management methods and techniques. Some studies refer to the hard and soft sides of TQM. Total quality management is an approach to the management of an organisation in which quality plays a central role and which is based on the participation of all of its members. The goal is long-term success, which can be achieved through customer satisfaction, and which benefits all members of the organisation as well as society. (Silen, 1998; Dale, 1999)

The development of quality management is often described in the literature as a four-stage process (Figure 3): the first stage inspection (I) can be considered to have started during the industrialisation and mass production. The second stage quality control (QC) began during the Second World War and especially in Japan after the war. The emphasis of the second stage lies in the manufacturing process, which is systematically developed.

The third stage, quality assurance (QA), incorporates the entire development and manufacturing process of a product as a factor affecting quality. In the fourth stage, total quality management (TQM), quality is seen in a holistic and strategic manner. At this point, the responsibility for quality was extended to include everyone in the organisation and the role of the corporate management becomes central. (Bounds et al, 1994; Dale, 1999; Hannukainen et al., 2006)

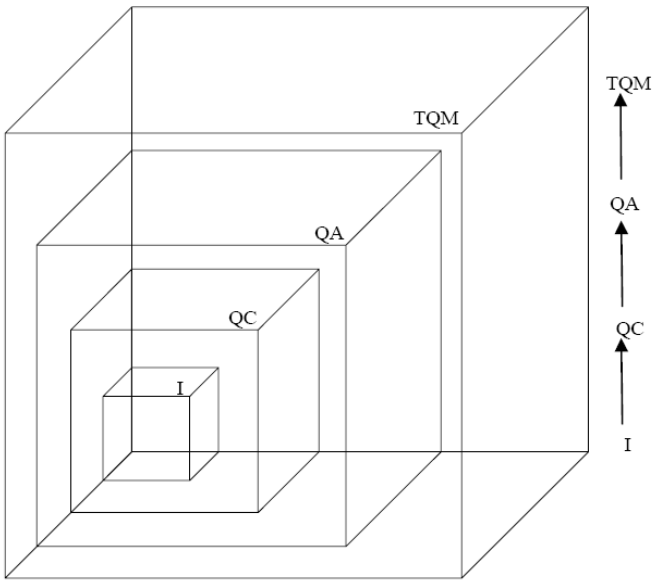

Figure 3: Development of quality management ideologies (Dale, 1999).

According to Hannukainen et al. (2006), the "Quality 2020" survey carried out by the American Society for Quality showed the following outlines: the application of quality thinking must become more innovative, more flexible and quicker to implement. The number of professionals working in the field of quality may decrease, but the need for quality-related skills will not. The trend seems to be towards the decrease of the importance of a quality department's role as a separate unit and making quality increasingly into everyone's concern. The challenge for specialists in the field of quality will be to develop to meet the needs of business and technology.

Comparison of the development paths

The development paths of EHSQ management areas are combined in Table 3. The comparison shows that each management area has, in slightly different pace, expanded during the last fifty years from a detail level to a holistic level. More viewpoints have been brought on every area, making them more complex to manage and affecting more functions and people in organisations. This inevitably leads to overlapping structures, which suggests that looking at these systems as a whole might result in improved efficiency and competitiveness.

Table 3: Overview of EHSQ development paths.

	Development of EM	**Development of H&SM**	**Development of QM**
-1950		1930s: Labor contract negotiations Rescue operations	I, 1931: Shewhart 1950s: Japan era in QM. QC; Deming et al.
1960	1962:Silent Spring published	1960-1970s: Many socio- and psychological theories of work developed	QA, Japan era continues 1962: Quality circles Ishikawa et al.
1970	Traditional EM - reluctant adaptation 1972: UN Stockholm conference and Limits to Growth	Research disciplines born Nordic model of occupational H&S 1975: Eurofound	TQM in Japan
1980	Modern EM - passive appraisal Sustainable development		TQM in America and Europe 1985: MBNQA 1986: Six Sigma 1987: ISO 9001
1990	1992: Rio de Janeiro UN conf. 1996: ISO 14001 Program thinking	1996: EU-OSHA 1996: BS8800, ISRS 1999: OHSAS 18001	1990s: "decade of quality" 1994: EFQM criteria
2000-	2004: Emission trading Program implementation Eco-competitiveness	2001: ILO-OHS Global safety and security Information safety	

The development of environmental and health & safety management has followed norms and regulations, while the development of QM has been driven by business needs of companies. Despite this, all three have developed towards similar holistic directions.

The historical development of EM and H&SM seem to be less researched than the development of QM in timeline format. This might be explained by the time span the areas have been developed intensively, the quality management begun roughly twenty years before the other two. EM and H&SM are also conceptually more diverse than QM, so describing them in a simple chronological way is more challenging.

INTEGRATED MANAGEMENT SYSTEMS

At the moment, there is no widely accepted standard equivalent to ISO standards for integrated management systems. The different integration levels in organisations pose a challenge for the making of a universal standard. (Jørgensen et al., 2006) The most commonly integrated management systems are quality, environmental and occupational health and safety standards. They are often based on widely used standards such as ISO 9001, ISO 14001 and OHSAS 18001 that include common characteristics and starting points, which make them relatively easy to integrate. (Zeng et al., 2007; Jørgensen et al., 2006; Wilkinson and Dale, 2001)

The organisation's culture and atmosphere must support the goals of integration and the willingness to combine different management systems. If not, integration will remain at the level of mere integration of documentation (Wilkinson and Dale, 2000). Jørgensen et al. (2006) also note the case-by-case nature of integration: there is no specific way to integrate management systems. The starting point is the organisation's culture and willingness to integrate. Successful integration depends on several factors, such as the content of the existing systems, field of operation, organisational culture and a number of other factors. (Wilkinson and Dale, 2001; Karapetrovic and Jonker, 2003)

The IMS model of Karapetrovic and Jonker (2003) is shown in Figure 4. It demonstrates how different management systems and the main interest group of the systems are linked. Like most model depictions of IMSs, the model has a continuous improvement circle built in it. It illustrates the idea that separate MSs should be first joined together at their interfaces enabling further integration into a holistic management system.

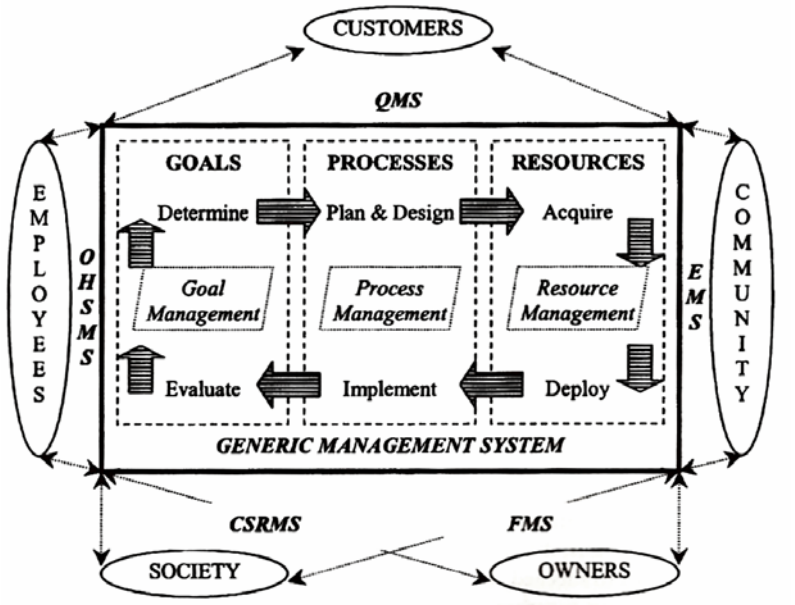

Figure 4: An IMS model of different management systems and their main interest groups (Karapetrovic and Jonker, 2003).

The IMS model by Wilkinson and Dale (2001) in Figure 5 highlights taking organisational culture into account in IMS implementation. In the model, the integrated quality, environmental and safety management systems are no longer independent and their role is to serve the entity in an integrated way, benefiting the entire organisation. Resources, personnel and processes have been divided between all previous systems. Goals are set and results measured jointly, which will create a circle of continuous improvement. The model joins all management systems tightly in order to create a common integrated system and cultural structure that are based on the key aspects of holistic quality management, such as teams, active participation and co-operation. In this way, it is possible to achieve a strong culture, which is divided between quality, environmental and safety issues, where core values and procedures of the entire organisation are based on holistic quality management. (Wilkinson and Dale, 2001)

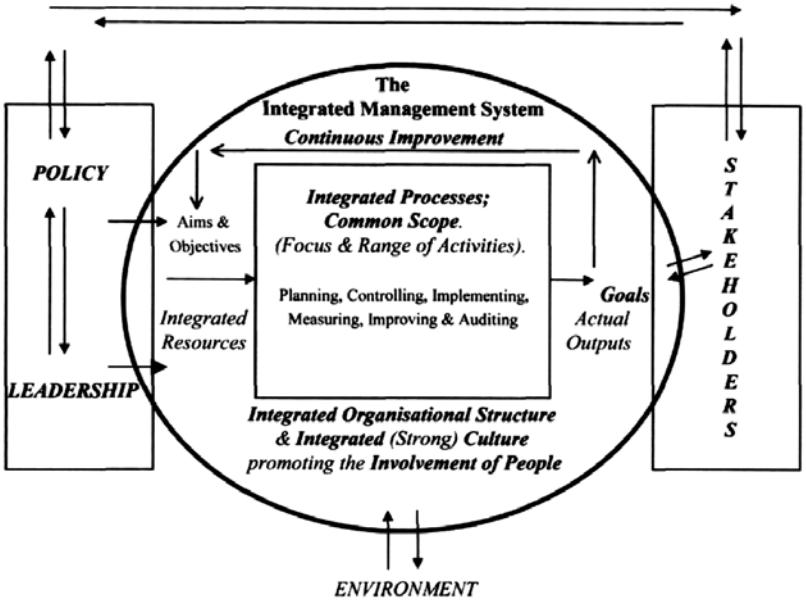

Figure 5: An IMS model highlighting the importance of culture (Wilkinson and Dale, 2001).

Where the previous models look at systems and organisational culture, the model by Zeng et al. (2007) in Figure 6 looks at IMSs from a synergy viewpoint. The levels included in the model are strategic synergy; organisational/resources, structural and cultural synergy; and documentation synergy. It demonstrates the flow in IMS implementation: from strategic synergy towards resources, structural and cultural synergy which lead to documentation synergy.

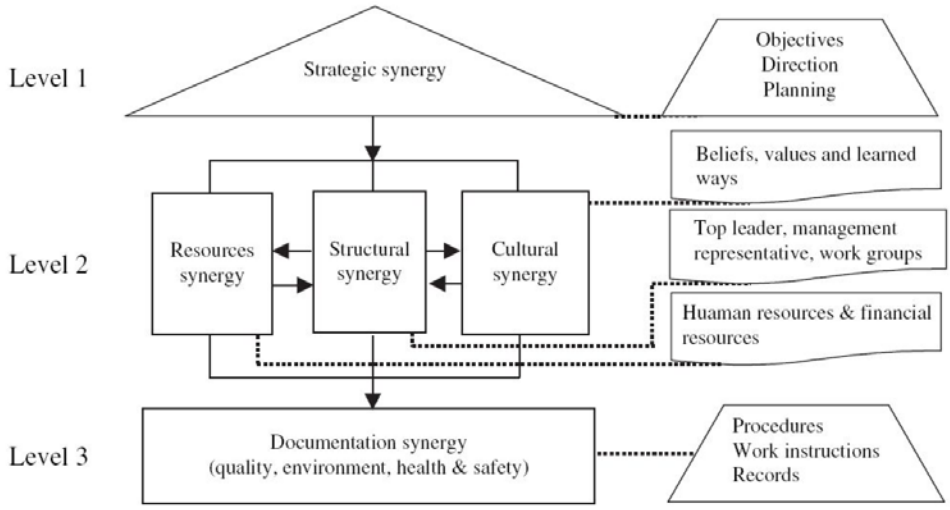

Figure 6: An IMS model from the synergy viewpoint (Zeng et al., 2007).

Asif et al. (2010b) recognise two strategies for implementing an IMS: a techno-centric approach and a systems approach. Their work suggests that maximum benefits are achieved through the systems approach, while the techno-centric approach mainly affects the organizational level. This finding supports the viability of the model proposed by Zeng et al. (2007).

Assessment of an IMS

How can the organization gain information on how its integrated management system is working? Setting and monitoring key performance indicators, both financial and IMS area specific metrics, can give information on this. This will give an idea if the system is working through whether the goals have been reached. It can also identify problem areas if goals are not met somewhere. However, metrics alone do not recognize improvement potential and synergies between different IMS areas. Metrics must be linked to the strategic processes in order to lead to results in an integrated way. (i.e. Zutshi & Sohal, 2005; Conti, 2006; Tervonen et al., 2009a)

There are several tools that can be used in order to reach the goals indicated in the organisational development model, such as models of business management excellence or holistic quality management such as the EFQM or the Malcolm Baldrige models. Regardless of the tool, the most critical point is the clear and accurate description of goals: what are the organisation's goals and what are the impacts of the organisation and its management system on the surrounding society (Conti, 2006). For the maintenance and progress of the system it is also necessary that a management review is held regularly with key personnel representing management from across the organization. (Zutshi & Sohal, 2005)

Figure 7 demonstrates a synthesis of EHSQ integration and their assessment as proposed by Tervonen et al. (2009a). The assessment is based on the CMMI maturity levels, against which the achievement of business goals is reviewed.

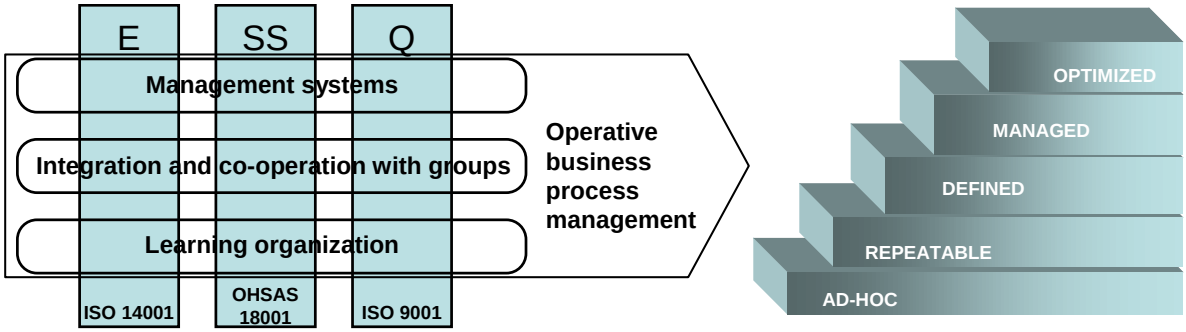

Figure 7: The integration of EHSQ management to operations and maturity levels.

BENEFITS AND CHALLENGES OF IMS

In figure n, Zeng et al. (2007) classified the synergies an IMS includes on three levels: 1) strategic synergy, 2) cultural, structural and resources synergy and 3) documentation synergy. Zwetsloot (1995) describes the synergies similarly, categorising them into common aspect synergy, management synergy and organizational synergy.

Casadesus et al. (2011) performed an empirical investigation on whether these synergies realise in practice using a sample of Spanish organizations with ISO 9001 and/or ISO 14001. Their results suggest that implementing them into an IMS brings greater benefits to the organization than having them as separate management systems. Their results showed a particularly large difference in customer satisfaction.

Zeng et al. (2010) identified the most significant benefits achieved by their case companies from IMS integration to be the simplification of certification processes, management cost savings and decreased paper work. In Zeng et al. (2011) two more benefits were pointed out: decreased complexity of internal management and facilitation of continuous improvement. Beckmerhagen et al (2003) suggest of prevalent benefits in more detail, the results of the Zeng et al. studies support these findings.

Zutshi and Sohal (2005) studied the IMS implementation of three Australian business organizations. The main IMS benefits they discovered were 1) Improved transfer of strategy to operations 2) Improved resource utililization 3) Better visibility for management through a holistic view 4) Improved acceptance and understanding of employees of different IMS areas 5) More effective integrated training programs 6) Enhanced communication 7) Positive bottom line and market image effect 8) Ease of auditing and housekeeping.

Beckmerhagen et al. (2003) point out that the integration of standards and the integration of systems is largely disconnected. Integration should be done gradually and the order of integration should be thought out. Full integration should include all the management systems of an organization and consist of an IMS core and function-specific modules. Their case study highlights an example in which safety management was not fully integrated, which led to non-conformance in that area.

Zutshi and Sohal (2005) found these challenges/impediments accompanied by integration: 1) People's attitudes and the resulting cultural resistance 2) Lack of a formal strategic plan and a planning process hinders MS integration 3) Lack of internal expertise to integrate, leading to the use of consultants which may not provide the desired results 4) Constantly changing regulations and guidelines 5) Insufficient capability of reporting results in a timely manner 6) Time-delays in integration.

CONCLUSION

The aim of the study was to look at the integration of HSEQ management from multiple perspectives. A view of what has caused the interest in integrated management systems and what is the current theoretical basis of integrated management systems was gained. The posed research questions were answered in the previous chapters. Below are the answers in a summarized form:

RQ1: What have been the development paths of different areas of EHSQ management?

Several observations can be made from the comparison of the historical development paths of the EHSQ management areas. The development paths have been led by different motivators. E and HS management areas have, especially in the past, been driven by laws and regulations, although recently a more active mode of development has been introduced, as the areas have become ways to gain competitive advantages. Quality management has from the beginning been motivated internally from the need to meet customer requirements effectively.

Despite different governing factors each area has progressed towards a more holistic view. The scope has shifted from a detail level, be it individual products, the operator of a machine or a single health or safety issue towards the organizational level. This increase in scope explains the need to adopt systems to handle these management areas. Multiple stakeholders, both internal and external, are constantly involved with each of the management areas and they become interlinked. The fact that this has happened only recently explains the IMS "boom" of the last decade.

RQ2: What elements does an integrated management system include and how can the efficiency of an IMS be assessed?

The current IMS view is to use existing MSs as building blocks that are combined into the organization's management process to form a holistic management system. As Beckmerhagen et al. (2003) stated, a fully integrated management system should include all the management systems of an organization and consist of an IMS core and function-specific modules. Through the strategy process, IMS goals and their indicators are defined and assessed through management reviews. It is possible to assess an IMS in more detail through the use of i.e. EFQM or CMMI models.

RQ3: What are the main benefits and challenges of IMS implementation on organizational success?

Integrated management systems aim to gain benefits for the organization by achieved synergy advantages. Zeng et al. (2007) classify these synergies on three levels: 1) Strategic 2) Cultural, resources and structural and 3) Documentation. Through synergy achieved through IMS implementation, concrete benefits such as simplification of certification, management cost savings, decreased paperwork, decreased complexity of internal management and facilitation of continuous improvement can be reached (Zeng et al., 2010; Zeng et al., 2011).

Challenges that need to be accounted for when implementing IMSs mostly relate to management actions and organizational culture. Recognizing the interfaces between different MSs during the implementation phase is important. Setting clear goals both for the implementation and the different IMS areas is crucial. Proper management support and leadership can lessen the cultural resistance to the implementation.

The framework presented in this study can be used to assess individual IMSs using the same structure: historical developments, elements and assessment and benefits and challenges. This can be seen as a well-balanced way to investigate an IMS.

This study focused on HSEQ management areas. Further insight could be gained by adding other areas in the analysis. An interesting topic would also be to analyse and compare several organizations using the history – elements and assessment – benefits and challenges structure.

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USING THE BCFI METHOD TO IMPROVE IDEA MANAGEMENT

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ABSTRACT

New Product Development is a starting point for many world-class innovations that originate in the minds of people. Along the development path they might become products or services that produce value for their developers, makers and users. The process where ideas become refined to start making (economical) sense to a company often begins unclear, fuzzy and completely unstructured. Companies and researchers today are doing what they can to clarify the processes therein in order to make innovation paths more structured, and to bind the activities to corporate strategies and existing technological roadmaps.

The case at hand was studied to improve the company's idea management in the front end phase. For this study, data was collected by means of a survey about the effects and importance of idea management to early-stage handling of new ideas. The results were then analysed with the Balanced Critical Factor Index method. For the method, specific information about the experiences and expectations of respondents in the case company was asked. The case company, a world-renown manufacturer, operates in the business-to-business market, and does business in several countries.

The Balanced Critical Factor Index (BCFI) method specifically showed that there were definite targets for development, according to the respondents' experiences and expectations. The study produced important information about the current state of idea management and the corporate culture around it. Based on the findings and the results, the corporate management will be able to focus attention to the critical areas, and enhance the knowledge culture by means of idea management. In the long run, the company's intention is to screen their ideas for feasibility already in their early stages, in order to pick the winning ideas for further development into world-class innovations.

INTRODUCTION

Corporate strategy dictates the guidelines for business in the modern company. The company management should be aware of the accordance of everyday to its chosen strategies at all times in order to run the business effectively and to make quality decisions. In order to accomplish this, the management needs timely information about the company's direction of development, both as historical statistics and future estimates. There are several ways to measure business activities, but selecting what to measure and the source for information are important to get eligible results that can be used for the purpose of business development.

The data was collected from a selected group of experts and managers who have a stake in the idea management process. Their future functions include coordinating the screening process for individual ideas, evaluating the ideas, and other supporting tasks. The intention has been to acquire data from several corporate levels in order to find out how the process measurement and the tools used in the process could be developed to match corporate requirements. The overall number of respondents for this study was 20 employees from both manager and non-manager levels.

THE BALANCED CRITICAL FACTOR INDEX METHOD

The Balanced Critical Factor Index (BCFI) method is used for data analysis. The method was first introduced as the Critical Factor Index (CFI) method by Takala and Rautiainen in 2003. Through further development by Takala & Ranta (2007) and Takala & Nadler (2010), the method has evolved to the BCFI method to de-emphasize the importance of standard deviations in the calculations. The method, originally developed to sense and respond to customer satisfaction, is used to find the critical attributes in business processes. It can be used for examining several types of different processes as a management tool to find the business-critical allocation targets for resources. (Nadler & Takala, 2010).

Data for this method is commonly collected by means of a questionnaire. However, because for each process within the company the attributes are individually applicable, a standardized questionnaire cannot be used. The questionnaire should rather be customized for each case in order to get reliable and accurate results (Nadler & Takala, 2010). The next section describes using the method in more detail.

Using the Balanced Critical Factor Index method

There are three separate phases in the BCFI method:

1) Assessing the current situation and making observations
2) Defining the appropriate attributes for critical factors
3) Data analysis and application of CFI tools

Phase 1 consists of preliminary research of the organization, its processes and the situation in general. This phase is meant for finding the appropriate phenomena and the correct organizational elements to research, in addition to getting acquainted with the processes and people whose input is required.

Phase 2 is about defining and selecting the relevant attributes to measure the business processes. The attributes are directly used in a questionnaire, sent to respondents that have key roles within the examined processes. The respondents are asked to respond their past experiences and future expectations about the processes, as represented through various attributes. They respond on a numerical scale where the higher end indicates better grading for attributes. Also, the opinion of respondents about past and future development is asked with the options 1) worse, 2) same and 3) better.

Phase 3 comprises calculating the following indices for data analysis, according to the BCFI method:

$$\text{SD expectation index} = \left(\frac{\text{SD of expectation}}{10}\right) + 1$$

$$\text{SD experience index} = \left(\frac{\text{SD of experience}}{10}\right) + 1$$

$$\text{Performance index} = \frac{\text{Average of experience}}{10}$$

$$\text{Importance index} = \frac{\text{Average of expectation}}{10}$$

$$\text{Gap index} = \left|\frac{(\text{avg.of experience} - \text{avg.of expectation})}{10}\right|$$

$$\text{Direction of future/past development index} = \left|\frac{(\text{b\%-w\%})}{100}\right|$$

The BCFI is calculated with the following equation, with values from the other indices:

$$\text{BCFI} = \frac{\text{SD expectation index} \cdot \text{SD experience index} \cdot \text{Performance index}}{\text{Importance index} \cdot \text{Gap index} \cdot \text{Direction of development index}}$$

Originally, the BCFI has been used with the indices for future and past development calculated together. However, depending on the results, it is more eligible to calculate them separately. Thus, it is possible to make a comparison between the perceived states of the attributes according to historical development and the future development direction. With this, it is possible to make a development statistic over time, as the attributes are measured in future instances.

Attributes are considered critical when their BCFI value is close to zero. If an attribute has a value significantly greater than others, it is also noteworthy. The separate indices can be weighted if there is need to emphasize them according to the prevalent circumstances (Nadler & Takala 2010, pp. 3–4).

The BCFI values are calculated individually for each attribute. The results can be presented as a bar graph that shows the BCFIs for both past and future development side by side. If results are needed for certain organizational elements (for example only manager-level personnel or for only certain units), the results can be divided accordingly and a separate graph should be made for each statistic.

RESULTS

The data was collected from a population of employees consisting of managers and experts. Their work locations are in Finland and other countries. A questionnaire with 28 attributes related to idea management was sent to the respondents. The results are presented in this section firstly as a summary of average scores, standard deviations and percentages for the direction of development (separately for future and past) for all questioned attributes. 21 replies in all were received for the survey. The table below shows the summarized raw data:

Table 1: Summarized raw data for the idea management survey

Idea management	Average of expectations	Standard deviation of expectations	Average of experience	Standard deviation of experience	Direction of future development			Direction of past development		
					Worse	Same	Better	Worse	Same	Better
Attribute 1	8,47	0,77	5,32	1,97	0,00 %	11,11 %	88,89 %	5,26 %	68,42 %	26,32 %
Attribute 2	7,82	1,07	6,56	1,86	11,76 %	35,29 %	52,94 %	0,00 %	75,00 %	25,00 %
Attribute 3	8,32	1,00	5,63	1,74	0,00 %	42,11 %	57,89 %	0,00 %	72,22 %	27,78 %
Attribute 4	8,05	1,08	5,05	2,09	5,26 %	21,05 %	73,68 %	5,56 %	83,33 %	11,11 %
Attribute 5	8,00	1,24	4,89	2,00	0,00 %	22,22 %	77,78 %	5,56 %	55,56 %	38,89 %
Attribute 6	6,69	1,78	4,13	2,09	0,00 %	50,00 %	50,00 %	6,25 %	62,50 %	31,25 %
General idea correspondence to strategy										
Attribute 7	7,61	1,04	5,67	2,17	0,00 %	66,67 %	33,33 %	0,00 %	83,33 %	16,67 %
Attribute 8	7,95	1,13	5,84	2,09	0,00 %	55,56 %	44,44 %	0,00 %	63,16 %	36,84 %
Attribute 9	7,63	1,57	5,95	2,25	5,26 %	47,37 %	47,37 %	0,00 %	68,42 %	31,58 %
Attribute 10	8,05	1,78	5,95	2,34	0,00 %	26,32 %	73,68 %	0,00 %	42,11 %	57,89 %
Attribute 11	8,32	0,95	6,32	2,11	0,00 %	42,11 %	57,89 %	0,00 %	68,42 %	31,58 %
Attribute 12	7,58	1,71	5,56	2,25	0,00 %	31,58 %	68,42 %	0,00 %	57,89 %	42,11 %
Importance of idea management for solution/product development in these areas:										
Attribute 13	8,21	1,13	6,42	1,92	0,00 %	15,79 %	84,21 %	0,00 %	73,68 %	26,32 %
Attribute 14	7,63	1,50	5,58	2,04	0,00 %	27,78 %	72,22 %	0,00 %	78,95 %	21,05 %
Attribute 15	7,84	1,80	5,84	2,09	0,00 %	27,78 %	72,22 %	5,26 %	52,63 %	42,11 %
Importance of idea management for operational development in these areas:										
Attribute 16	7,05	1,43	5,17	2,20	0,00 %	55,56 %	44,44 %	11,11 %	77,78 %	11,11 %
Attribute 17	7,20	1,58	5,47	2,09	0,00 %	47,37 %	52,63 %	10,53 %	78,95 %	10,53 %
Importance of idea management for business development in these areas:										
Attribute 18	7,59	1,54	5,59	2,06	0,00 %	41,18 %	58,82 %	5,88 %	70,59 %	23,53 %
Attribute 19	7,76	1,52	5,63	2,45	0,00 %	25,00 %	75,00 %	0,00 %	68,75 %	31,25 %
Idea collection										
Attribute 20	8,50	1,05	4,75	2,17	0,00 %	10,00 %	90,00 %	5,00 %	75,00 %	20,00 %
Attribute 21	7,75	1,33	4,42	2,27	0,00 %	21,05 %	78,95 %	5,26 %	73,68 %	21,05 %
Attribute 22	7,79	1,69	3,94	2,75	0,00 %	22,22 %	77,78 %	5,88 %	76,47 %	17,65 %
Attribute 23	7,56	1,29	4,25	2,74	0,00 %	23,53 %	76,47 %	6,25 %	81,25 %	12,50 %
Improvements by idea management to these attributes										
Attribute 24	6,88	1,26	5,20	2,04	0,00 %	46,67 %	53,33 %	0,00 %	64,29 %	35,71 %
Attribute 25	6,95	2,32	5,28	2,44	21,05 %	52,63 %	26,32 %	5,88 %	82,35 %	11,76 %
Attribute 26	7,80	1,20	4,89	2,00	0,00 %	31,58 %	68,42 %	5,56 %	72,22 %	22,22 %
Attribute 27	8,00	0,97	5,18	2,32	5,88 %	23,53 %	70,59 %	6,25 %	68,75 %	25,00 %
Attribute 28	8,10	1,52	5,84	2,06	0,00 %	36,84 %	63,16 %	5,56 %	77,78 %	16,67 %

Some conclusions can already be made from the raw data. It seems that attributes 6, 24 and 25 have received the lowest average scores. Also, the standard deviation of attribute 25 is significantly larger than other attributes. This indicates that there is ambiguity about the attribute. Regarding past experiences, attribute 6 also had a very low average score, which means the expectations for this attribute are pessimistic, despite the direction of future development is expected to become either better or stay the same.

Attribute 20 has received the biggest average score, and its direction of future development has ultimately the most responses on “better”, which indicates this as a strongly noticeable attribute for future development.

Results from the BCFI method

The BCFI method yielded results for both the future and past development separately. From the shape of the figure below, it can be seen that there is more ambiguity and unawareness of the past circumstances in various attributes than in the expectations for the future. Although for such attributes as 4, 16, 17 and 25 the values for the past BCFI are significantly bigger than others, the scale values in the figure below are limited to 10 in order to keep the diagram readable. The results for both future and past BCFIs are displayed in figure below.

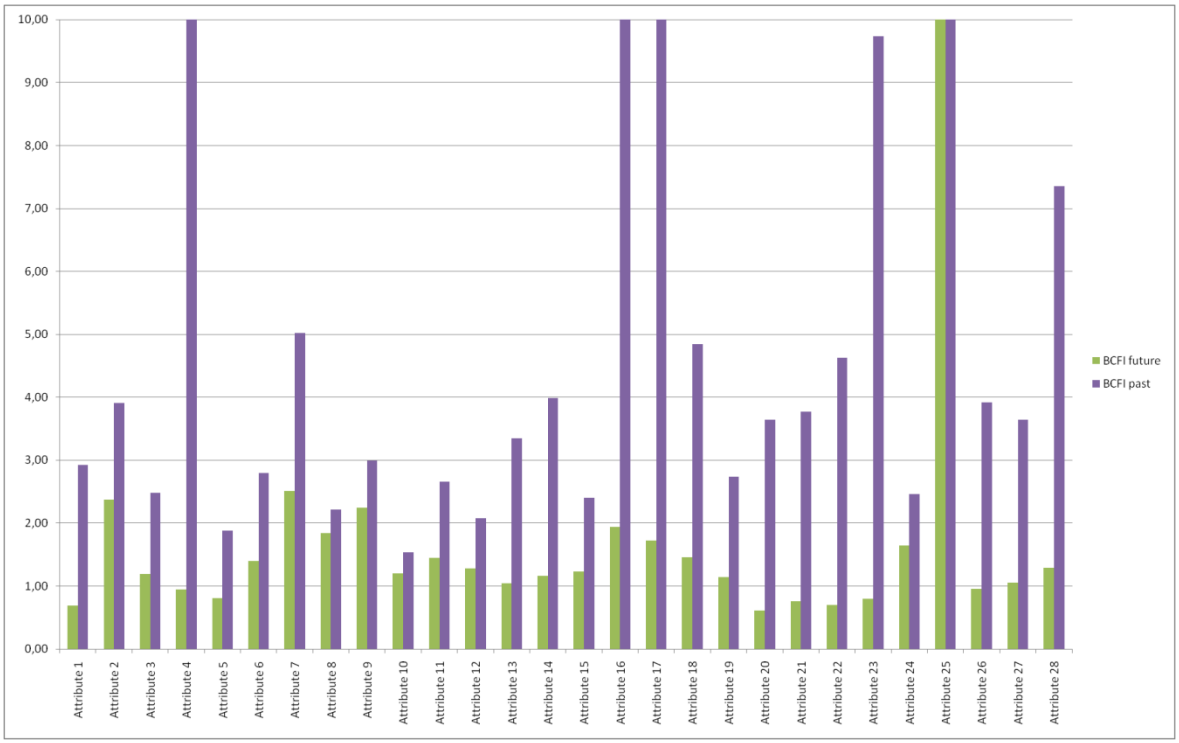

Figure 1: Future and past BCFI

From the figure it is seen that the values for attributes 1, 20 and 22 are the most critical. This coincides with previously collected data and confirms the need for development in these areas. The attributes have been identified as lacking historically, and the respondents' expectations for improvements make it the focus for future development.

The peak values in attributes 16, 17 and 25 show that these particular attributes are not considered critical. Therefore, there is no imminent need for development. The nature of these attributes suggests that with any development to other (critical) attributes, the ones in question will also be improved.

The past BCFI values show several peaks in attributes 4, 16, 17, 23 and 25. These attributes are either non-critical or otherwise there has not been a common view on them between the respondents. Previously collected data indicates that these attributes have not been in use much, which explains the ambiguity around them.

CONCLUSIONS

The study was made to find out the critical attributes for the development of idea management in the case company. The BCFI method gave valuable results based on the expectations and experiences of company employees both on manager and expert levels. It clearly showed that the company is strong in some attributes, mainly around its core competencies. The method also indicated that idea management is a necessary, albeit ambiguous function, and requires the company clearly defined rules and connections to its processes.

The BCFI method was found to be most effective when the indices were separately handled for the future and past development. In both indices, the critical values correspond with previously collected data well and provide valuable information that will help the case company to develop its business with the studied function of idea management.

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A CASE STUDY ON CHINESE FAILURE IN ERP IMPLEMENTATION

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ABSTRACT

This article is a single-case study on ERP implementation processes at a Chinese enterprise. The enterprise, Ω, implemented the second generation of ERP system supplied by SAP R3 to supersede its earlier own custom-designed first generation ERP system. We selected five Key Critical Success Factors (KCSFs) of; top management support, business process re-engineering (BPR), change management, project management, and company context for analysis of second generation ERP SAP R3 implementation at Ω. The primary reason for change over from first generation to second generation ERP SAP R3 was business expansion and modernization. Ω failed to customize SAP R3 to its business processes. There were variety of reasons for this failure with amongst others, users' resistance, company culture, complex business processes, error in input to database, lack of understanding of business processes by SAP consultants and understanding of SAP functions by key users.

Keywords: Change management, Project Management, Business Process Re-engineering (BPR), Culture.

INTRODUCTION

Ω is one of China's largest microscope enterprises, claiming to be the fifth brand in the world. The enterprise was established in 1983 in Xiamen, and now it has six subsidiary companies all over the world: Hong Kong, U.S., Canada, Germany, Spain, and U.K., with over 2500 employees. Ω at China, Xiamen is the production HQ and the manufacturing center and technology development centers. Chengdu, Guiyang, and Sanming production plants produce different components of the microscope. Since most of its sales are for overseas, Hong Kong is the international marketing and sale center. Ω Enterprise founded by purchasing Xiamen Optical Instrument Factory, a state-owned company, and taking over all its employees. Ω has built international reputation from its Hong Kong based investments, international business and its state-owned legacy. Due to its state-owned background, government has influence on Ω business affairs.

Ω specializes in manufacturing of both conventional microscope and digital microscopes. The main product, i.e. digital microscope, is used for education, lab research, industry measurement, and medical application. On this perspective, Ω is also a high-tech company. It possesses a Research & Development center, which integrates sub-divisions of optics, mechanics, chemical, industry design, electronic, software, and it has over 100 professional engineers and technicians. The Ω technology high-tech know-how is a key success factor in

ERP implementation efforts.

The ERP Implementation at Ω

Motivation behind ERP Implementation at Ω

Begin 1999, **Ω** planned to implement ERP in the period when most Chinese firms were eager to change from business expansion to modern high-tech business. Ω aimed at developing technology innovation and expansion in both domestic and global market share. A number of problems aroused from the firm expansion. For this reason, Ω searched for effective and advanced management tools to support its business processes to resolve the problems:

-Since the headquarters for; the marketing and sale center, manufacturing center, and technology and development center are at different locations and far from each other, the real-time and reliable communication and cooperation has been the most urgent problem.

-The product serial numbers outdated and malfunctioned because of rapid new development and products updates. For instance, the same type of digital microscope, customized for different companies, and ordered by different serial numbers enhanced the problems in resource management.

-One complete set of digital microscope comprise of hardware and software, which each also contains several components. Different departments had their own ways to mark them, i.e. the same part of the product has more than one tag number. This was the cause of some communication problem.

-The information flow has been phase-by-phase and slow.

-The database for daily activity had functional limitation because of data expansion.

-In addition to State publicity, ERP implementation trend influenced the Ω top management decision on ERP implementation.

These problems were present in Ω prior to ERP SAP R3 implementation, while the top management had its own reasoning for ERP adoption.

The first generation own custom-designed ERP implementation

In this section, the analysis for the first generation of ERP system is based on the process model developed by Ross (1998). In an ERP implementation model, Ross (1998) links the process stages to organizational performance. The following section presents how the custom-designed ERP system developed and performed at Ω.

- Design Stage

According to Ross (1998), the decisions timeline has to be determined; including changing business processes or ERP customization period, and period for determination of process

standardization domain must be specificed. Ω decided to design and implement the ERP system by itself, and for this reason it selected some experienced programmers to learn how to design the ERP system. On one hand, the custom-designed ERP system focused in solving the most urgent problems and potential problems what considered by CEO as most critical to firm operation. On the other hand, the software programmers involved in design of ERP system were not ERP experts, and they had limited knowledge on ERP functions.

- Implementation Stage

At this stage, firm starts with ERP implementation, and some problems emerge because of the new system. It will take time to take the problems and then, the effects come out (Ross, 1998). In this case, the ERP system was designed to solve the existing problems and Ω was less flexible users towards this ERP system. Initially, the ERP system was a small module, aiming to solve the serial number for different products. There were limited number of users and departments involved. The system was implemented smoothly because of 1. Training, 2. Phase by phase implementation, and 3. Users' acceptance.

This ERP system was based on following three modules: 1) Planning: Planning includes MRP (Material Resource Planning) simulation, purchase orders application, short resource checking. It was mainly to provide the general resource schedule for the next manufacturing set. 2) Manufacturing: This involved receiving orders from Hong Kong, and arranging the manufacturing orders to sub-manufacturer. In this function, ERP acted as a link among the headquarters (Xiamen), the sale center (Hong Kong) and sub-manufacturing company (Chengdu, Guiyang, Sangming), and 3) Resource management: Resource management included tracing of purchase orders, and adjusting the resource order in case there was any priority order.

- Stabilization Stage

Firms take benefits from the ERP system, if it performs its functional expectations in implementation stage (Ross, 1998).

Ω entered stabilization stage at the end of 2000 at which some of the above mentioned problems were resolved. For instance, the disorderly product serial numbers were organized, and this enabled the product parts to have unified identification codes.

The basic access to the resource database allowed the subsidiaries to have a real time input and output for all resources, which had facilitated the resource management. In general, the improvement in communication, coordination and cooperation based on the three modules (planning, manufacture, and resource management) formed effective supply chain for Ω; and Ω had a better performance than before.

- Continuous Improvement Stage

After the stabilization stage, the change in business environment must force companies to roll out change management throughout the organization. The ERP system also has to be improved according to these changes, with the development of new functions (Ross, 1998). Since 2002,Ω launched its focus on the digital microscope instead of the conventional microscope. The transfer of the products led to the ERP updates, which increased the requirement for an increase in database capacity for recording more microscope categories and parts. This included different types and parts of hardware and different versions of software. However, problems were that the new products, digital microscopes, developed more problems, especially after integration of hardware and software. This required more efficient and sufficient information exchange throughout the entire value chain. In this aspect, ERP system played a critical role in information collection and information sharing. With the ERP support, Ω aimed to develop more businesses at domestic and global markets.

- Transformation Stage

At this stage, firms use ERP system to perform process reengineering and to increase their business margin; however, firms have seldom reached this stage (Ross, 1998).

The firm expansion brought various changes to both organizational structure and business activities. There was more demand on the customer specific requirement. The firm had to put more product attributes for custom-designed product. In a Digital Lab, Japanese prefer the monitor of the students' microscope by; while the western focus is on the real time communication between teacher and students. ERP had to reflect broad customers' requirements, and assign tasks to each department to fulfill these requirements. The custom-designed ERP failed to support these complicated process requirements, and the system appeared to regenerate more problems gradually. By taking all the factors into account, the reasons for ERP change-over can be explained as follows:

The function and module of first generation ERP system was difficult to develop and expand to other functions and descriptions.

The ERP system was designed and developed by in-house Ω programmers. They had no or less knowledge of ERP systems and less capability to forecast the changes in business processes, and to understand marketing focus, and management structure. The design of the system was all based on the situation at that time, and there was less flexibility for further development. In addition, at technical level, there were unexpected bugs in the first ERP generation, and Ω had no experience how to trouble shoot the bugs.

Ω had developed with progressive changes in its organizational structure, management model and manufacturing processes. Thus, secondly, first ERP generation did no longer fit to organizational business processes. The system was difficult to modernize and it was no longer suitable for the enterprise.

The system had fatal limitations, which slowed down the ERP system developing in parallel

with organizational changes. Finally, the gap between the system and actual business processes became a barrier to Ω further business development in the market. Despite all, the first generation of ERP system was successful in achieving its objectives for the lifetime of product.. It improved the resource management at Ω, and it synchronized the flow of resources among different business units. The large boost in Ω revenue owed to this ERP application. However, considering the ERP shortcomings and opportunity costs, Ω decided to supersede the first ERP generation system by a professional ERP system.

The second generation off-the-shelf ERP SAP R3 implementation

Ω chose SAP R3 for their new business processes. Since 2005, the ERP experts worked at Ω on ERP implementation project. The ERP SAP R3 implementation process took the following implementation phases;

- Chartering Phase

In 2004, the CEO decided to to replace the out of date inhouse ERP with a new ERP SAP R3 system. Ω made a comparison among different ERP vendors, such as Yongyou, Oracle, and finally he chose SAP R3. SAP was recognized as the most advanced and flexible ERP system for Ω application. After the final decision on SAP R3 implementation, SAP consultant started with their business process study at Ω. At this phase, Ω held several meetings to introduce the business processes and firm database to SAP consultants

- Project Phase

Ω outsourced ERP SAP R3 implementation project to SAP. In order to provide the critical process operations of different department, Ω built a SAP team consisting of the key users in each department. SAP held several trainings for these users involved in the ERP SAP R3 system.

In begin 2007, the ERP SAP was pilot tested for about two months atΩ. The basic results were in accordance to the expectations, and SAP rolled out SAP R3 implementation in entire organization.

- Shakedown Phase

At this phase, Ω worked on the adaptation to ERP SAP R3 system, and it adjusted the ERP SAP R3 system to its live business processes. There are temporary problems like 'reduced productivity' and 'business disruption' in the beginning of this phase (Markus & Tanis, 2000). Ω faced the same situation with unpredicted problems emerging and causing business disruptions. There were some system bugs which were not discovered during the test stage. For instance, since the design of the system omitted the function 'software serial number management', this function was realized manually, or by the old ERP system. For this reason, the new ERP SAP R3 system operated in parallel with its predecessor.

- Onward and Upward Phase

At this phase, ERP SAP R3 system had to be stable and profitable. Ω did not reach this phase, and ERP SAP implementation required a great deal of improvements.

The implementation of SAP R3 moved to its third phase. The problems which the first generation faced had been considered in the design of the new ERP system. There were more modules in the new system to fit the more complex business operations. Ω emphasized on upgrade of ERP system to meet the requirements for a dynamic business environment. However, more difficulties became more visible, and the new ERP system seemed difficult to adapt to, and some of the functions were not flexible enough. There was a gap between the new ERP system business processes and the live business processes at Ω. Ω became a little bit anxious since the system did not function to users' expectations, and the problems were hard to overcome.

ERP SAP R3 Implementation Critical Success Factors Model

Ω encountered many problems in ERP SAP R3 implementation process. We analyzed the ERP implementation process on the basis of five KCSFs at Ω.

-Top Management Support

The implementation of ERP system involves the entire firm involvement, and it can't be successful without the top management understanding, support and participation (Davenport, 1998; Holland, 1999; Esteves & Pastor, 1999; Z.X. Chen, 2001; Yang W. S. & Yan H. H., 2001). The support from the top management is significant for the success of ERP implementation.

In details, the executive support could be *involvement* and *participation* (Jarvernppa & Ives, 1990): Involvement is a subjective and psychological concept, reflecting the cognition and attitude towards the information system. Low involvement illustrates that the executive considers the information system as a common technical project. As Davenport (1998) argues, only the top management possesses the capability to solve the conflicts between the business activities and technology.
The participation is the concept of activity, which refers to the investment on the projects, including time, money, concentration and so on (Jarvenppa & Ives, 1991). The executive support should be at strategic level, not only considering the budget, but also organizational innovation, management and culture, aiming to remove the resistance to ERP system.

At Ω, the executive had highly involved and participated in the ERP implementation. Initially, Ω budgeted 10 million yuan available to ERP SAP R3 implementation project required capital. Secondly, Ω required its staff to cooperate with ERP implementation SAP team, which assured the supports from "soft" factor. Thirdly, the executive played an important role in selection of the ERP supplier, the build-up of ERP project team, and negotiations with ERP consultants.

It was obvious that top management gave importance to the ERP SAP R3 implementation project. However, the problem was the top management sometimes took over the project management role, making decisions for the ERP implementation process. Some of these decisions pushed the ERP system into predicament.

-Business Process Reengineering (BPR) versus Customization of ERP System

As for information system, ERP is a tool which supports the firm to conduct change management; as for management method, ERP is a change management strategy (Esteves (2002). It is generally considered that BPR is essential for the success of ERP implementation (Davenport, 1998; Holland et al., 1999; Zhang et al, 2002; Guo & Tang, 2001). The *best practices* that ERP system advocates may misfit the organizational structure, operational procedures, management model, and infrastructure of the legacy system (Soh et al., 2000; Shang & Seddon, 2000). Therefore, firms have to minimize these misfits by balancing the BPR and ERP customization. According to Soh et al. (2000), the greater the organization changes, the better for ERP implementation is anticipated.

In ERP implementation process, the customization of ERP software is common for the enterprise. According to organization configuration; it is impossible to adjust ERP system completely to the previous organizational and business operation characteristics. On one hand, refining the ERP software is not an easy job, and it can trouble the maintenance in future; On the other hand, ERP is an advanced management concept, which the *best practices* has already been designed embodied in the ERP software (Soh et al., 2000). Adjustments on the system will be difficult to realize the potential benefits from ERP (Al-Mudimigh et al., 2001).

ERP is considered to be the new technology which can bring fundamental innovation on organizational and change management. Chen & Ye (2002) even regards ERP itself as a kind of BPR.

Similarly to Soh et al.'s (2000) point of view, Shang & Seddon (2000) created a matrix with four strategies to achieve fit in an ERP according to two dimensions: 'preparedness to change the enterprise application software' and preparedness to change organizational processes.

Shang & Seddon considers that system exploration create most value for the company among these four strategies; next are software modification & enhancement and process modification & enhancement.

Prior to ERP implementation,Ω business process was complex and inefficient. Because of widespread office locations in HK, Chengdu, Guiyang and Sanming, the communications between these centers were an issue.Ω expected that ERP SAP R3 system could resolve these problems.

Ω implemented the first ERP generation based on the strategy of *software modification & enhancement*, because there was no change in organizational business processes prior to the implementation. The system design and implementation were all aiming to solve the existing problems. The problems did not completely settle down by ERP implementation since the SAP R3 system could not improve the business processes. The failure to improve the Ω business processes was the main reason for the ERP failure.

SAP provided the second generation of ERP for Ω with the design concept based on the western business and management model. The Chinese enterprises have strong characteristics of their own, especially with the Chinese culture and state-owned background. The traditional management model and organization structure of Chinese enterprise differed from that of in West. in addition, Ω had its own company culture different from other Chinese enterprises.

A review of Ω business processes showed that customization was a complex process at Ω. The external SAP ERP implementation team did not understand the chaotic business processes and a mass of data from different subsidiaries. This led to some obvious bugs. One of the bugs was that the ERP system did not contain the price module for Digital Lab products (one of the most saleable products), so, Hong Kong could not check the price through ERP system. They requested the price from colleagues in Xiamen. This was a small error and easy to refine at the design stage. It decreased the efficiency of the whole supply chain and added trouble to entire business operations. That was the reason for manual operation of second generation ERP SAP R3 system.

Ω learnt that ERP system was not a tool for to settle with all the management problems or to solve the organizational process problems automatically.

Ω did not create the business process work responsibility for each department clearly, and it did not unify materials serial numbers and standards prior to ERP implementation. As a result, ERP SAP R3 system did not manage to support the materials efficiently. The serial number for each product part was not assigned in a systematic order. The initial input data to ERP SAP R3 system had no uniform or consistent system. This caused the ERP SAP R3 system to lose its key and basic function in resource management.

-Change Management

Change management focus is on how to deal with users' resistance. One of the important reasons for ERP failure is change management, since many problems in the ERP implementation arise from users' resistance (Kelly et al. (1999) and Sumner (1999)). Any resistance from individuals or functional groups can endanger the success of ERP implementation. Change management, with in particular, the management of users' resistance has been a real challenge to ERP implementation process.

The emotion for changes amongst the key users was the key critical failure factor in implementation of second generation of ERP SAP R3 at Ω. The reason was because some of the users had participated in the design and implementation of the first generation ERP

system; while the second generation ERP system was all designed and implemented by SAP. The emotional resistance was to the extent that key users were reluctant to contribute to the ERP SAP R3 team and ERP R3 implementation process.

This was despite their familiarity with Ω's ERP environment and their potential critical roles in success of SAP implementation.

The new ERP SAP R3 system was more complete. It contained more functional modules than the previous Ω own custom-designed ERP system. However, users were used to the simple operation of the old system. Users found the new system hard to operate. The reasons for users' inadequacy were inadequate training and narrow focus on certain ERP areas.

With implementation of new ERP SAP R3 system, there were more changes in the business processes at Ω. This demanded new relationships, interface and situations in enterprise. The work responsibility became ambiguous, especially for cooperation between teams and individuals. Users felt unstable because of the technical and management changes they encountered. Ω did not invest enough on smoothening of the changes during the ERP implementation.

-Project Management

ERP implementation is a considerable investment. It is a lengthy information-based project, involving the overall operations within an enterprise.

An ERP project has to draw up detailed requirements, target planning, and formal implementation schedule (Somers & Nelson, 2001; Chen & Ye, 2002). ERP is viewed as a process oriented IT tool, which the specific target or business vision has to transfer into the measurable mission or tasks (Al-Mashari et al., 2003). Without the definite business target, the ERP implementation may become a software installation project, and the implementation team would lose their direction, finally the system would be useless. It is essential that the project manager possesses experienced IT background, familiarity of the business process and organizational environment, as well as excellent communication skills. Moreover, most important thing is that the manager has to be empowered (Scott & Vesssey (2002) and Somers (2001)).

At Ω, the first generation ERP implementation team was familiar with business processes and organization infrastructure. Though, they lacked formal ERP implementation requirements, target analysis, and step-by-step implantation plan. The project was more like problem solving rather than a management tool. Consequently, the first generation ERP system developed many limitations over the years, and it no longer fit the business processes at Ω.

The implementation team for second generation of ERP also encountered a great deal of problems understanding complicated business processes and organizational structure. Ω

held extensive meetings and brainstorming sessions for SAP implementation team to understand the firm business structure and business processes.

Despite all efforts, the post ERP implementation system still developed a big bug. Overall, there was a huge gap in understanding Ω business processes and operation of the ERP SAP R3 at Ω.

-Company Context

Ω is a middle size company with several subsidiaries at different locations. Ω devoted a large budget to ERP SAP R3 implementation process.
The Chinese culture had an impact on ERP SAP R3 implementation process, especially at Ω, which had a state-owned background. The management at Ω was heavily hierarchical, and seldom empowered by middle or low level management. ERP systems which derive from western culture require empowerment and information sharing (Davison, 2002). At Ω, CEO made all the decisions, ranging from the business strategy to authorization of daily expenses at Ω. Every decision in the ERP system had to go through authorization of the CEO. Chinese culture follows 'rule of man', and the decision making is based on the experiences rather than the information system.

ERP system requires each activity to follow the designed practice, which means the business process activities rely on the regulations. Identification of regulation and unification of the standards in each department were significant processes to ERP SAP R3 implementation at Ω.

As a state-owned enterprise, Ω was influenced by politics (Liusong, 2001). Many Chinese firms adopted ERP system because the ERP system was considered to advance their management and technology tools. To catch up with high technology and modern management, Ω decided to implement ERP SAP R3 system without careful business analysis and acknowledgement of detailed requirements for implementation.

A typical Chinese characteristic advocates that the organization should be stable and harmonized. The users may reject the information system which breaks the previous internal relationships within the organization. They work hard and efficiently; but they are indifferent, and they avoid troubles, by shifting the responsibility to keep their job secure. For this reason, change management could have played a critical role in success of ERP implementation process at Ω.

Prior and post implementation of ERP process was with a lot of changes and staff brain drain, with software department in particular. Ω invested to a great deal in training the new users. Due to complex business processes and databases, critical users at each department experienced how the businesses worked in their domains. These critical users were not always the managers. The ERP SAP R3 implementation most of all needed the support of these critical users. With departure of these critical users, the difficulties with ERP SAP R3

implementation and post implementation process enhanced to the failure of implementation objectives.

CONCLUSION

Strong support from top management had positive impacts on ERP implementation process whereas weak BPR, resistance by key users, hierarchical autocratic culture and SAP R/3 misfit were among reasons for partial ERP customization and implementation failure at Ω. In this paper, we aimed to identify the KCSFs of two ERP implementation processes in a Chinese enterprise. We selected five KCSFs for analysis: top management support, BPR, change management, project management, and company context.

We drew up the following conclusions on the five KCSFs of ERP implementation:
Top management support had positive impacts in ERP implementation. However, the traditional Chinese management concept with hierarchical management, could lead the top management support to an autocratic control.

BPR was one of the most important factors in an ERP implementation at Ω. We learnt that the balance between BPR and customization of ERP software will have to be carefully considered prior to ERP implementation and in the course of ERP adoption.
Change management was the most important KCSF in ERP implementation at Ω. In China, the level of enterprise IT integration has been relatively lower in comparison to IT integration in Western countries. The user resistance has been higher towards both IT integration and ERP adoption.

Project management role was undermined at Ω because of the strong power of top management. The ERP project was little empowered by middle and low level management. As a result, it lowered the motivation for participation and ERP application.

Company context influenced ERP implementation process at different levels. The Chinese culture with a hierarchical management model and with characteristics of Chinese users had negative impacts on an ERP project at Ω.

Based on the analysis of the ERP implementation KCSFs of at Ω, we also concluded that Ω had to facilitate the information flow throughout the supply chain across Ω to improve the resource management and order management. The ERP implementation had to focus on solving the issues of resource management and order management. The implementation process had to be well planned and each step had to take the firm actual business processes into account.

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APPLYING THE DISTEH METHOD TO ASSESS THE FIRM'S INNOVATION POTENTIAL: A ROMANIAN CASE STUDY

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ABSTRACT

Lots of research work is focused on innovation. The theory is based on concepts as: innovation, innovative individuals or organizations, innovation potential / capacity, innovation capability. The practice is centered on innovation assessment or audit, and innovation management. In the process of designing the company strategy, it is critically important that top management becomes familiar with the competitive advantage of their company in the area of innovativeness – as the innovation capability has a leverage effect: if applied, the competitive advantage is considerably amplified.

Based on the authors recent research work on innovation potential of the small and medium size firms, the paper aims at applying the DISTEH method for assessing the firm's innovation potential. This method was successfully applied in the case of a Romanian firm active in the media industry. The results prove to be useful for the company managers who are making decisions to enhance its innovation potential and, therefore, competitiveness.

The implications are of high importance for practitioners (entrepreneurs and managers) as well as for the researchers and academics interested in developing tools to assess the firm's innovation potential.

Keywords: innovation, innovation potential assessment, DISTEH method, Romania

INTRODUCTION

Innovation potential may be assessed either at macroeconomic or microeconomic levels. As example, the MERIT Centre (Maastricht Economic and social Research and training centre on Innovation and Technology) is publishing studies on innovation in the European Union Member States (MERIT, 2008). However, most of the research and literature is focused on the company as the innovation generator.

Any company has a potential to be creative and innovate. According to Goffin and Mitchell (2005), the innovation drivers are: changes in the clients' needs, changes in the business environment, growing competition, and new technologies.

Innovation is a complex process (Rüggeberg, 2008); its theory is based on concepts as: innovation, innovative individuals or organizations, innovation potential / capacity, innovation capability. Innovation was defined by prestigious scholars (Kuhn, 1985; Wolfe, 1994; Drucker, 2000; Wolpert, 2002) – to name just a few.

The practice is currently centered on innovation assessment or audit, and innovation management. The process of innovation assessment is known as innovation audit as well, mainly in the German school (Eckelmann, 2002; Herstatt et al., 2007). In the process of designing the company strategy, it is critically important that top management becomes familiar with the competitive advantage of their company in the area of innovativeness – as the innovation capability has a leverage effect: if applied, the competitive advantage is considerably amplified. Such companies are well-known for their excellence in innovation (Warschat, 2005) or innovation excellence (Nilsson et al., 2010). The innovation capability, intimately linked with the entrepreneurial capabilities (Alvarez and Barney, 2000), is assessed in order to provide strategic tools for companies' managers.

The focus of this paper is to test the use of the DISTEH method (Scarlat, 1980, 2000, 2005c) for assessing the firm's innovation potential – in the framework of a more comprehensive model for assessing, analyzing and continuously improving the firm's innovation capability (Alexe, 2010). Assessing the innovation potential is just a stage of this complex process.

Based on the authors' recent research work on innovation potential of the small and medium size firms (Scarlat and Alexe, 2010), the paper present the results of applying the DISTEH method for assessing the innovation potential of a Romanian small business. The strengths of the method are highlighted – as it has previously applied to investigate innovative technologies as well as technology prediction (Scarlat 2004, 2006). The method was successfully applied in the case of a Romanian firm active in media industry and – according to the – seven groups of innovation factors were analyzed (conceptual – firm's philosophy on strategy, company culture, organization, personnel, technology, learning capability, economic and financial performance) comprising 95 criteria as a total.

The results of the experiment prove to be useful for the firm's managers who have made decisions to enhance its innovation potential and, therefore, the firm's competitiveness. The implications are of high importance for practitioners (entrepreneurs and managers) as well as for the researchers and academics interested in developing tools to assess the firm's innovation potential.

The remaining of this paper is structured as follows: Assessment of the firm's innovation potential; DISTEH method, Case study: The Company IMG, Conclusions.

ASSESSMENT OF THE FIRM'S INNOVATION POTENTIAL

In March 2011, Google search for "innovation potential" has generously offered approx. 5,000,000 items in 0.22 seconds and for "innovation capability" displayed in 0.25 seconds only 2.600.000 items!

In order to avoid any confusions, for the needs of this study, it is agreed that the concept of 'innovation capability' is larger than 'innovation potential': as described by Alexe (2010), the model for assessing and continuously improving the firm's innovation capability is a ten-stage process – in which the assessment of the firm's innovation potential is one of the stages only (Table 1). The model is an adaptation of the methodology of the Fraunhofer Institut (2007) to improve innovation capability while the method to assess the firm's innovation potential is largely inspired by the methods developed by Eckelmann (2002) and Arthur D. Little (2002). The main features of this process are summarized in Table 1.

Table 1: Model for assessing and continuously improving the firm's innovation capability.

No.	Stages	Content briefly	Participants
1.	Planning stage	Stages, activities, timing, outcomes Participants	Top management
2.	Define the company profile	Data collection, questionnaire-based Design the company innovation profile	Management
3.	Assess the managers' and employees' attitude towards innovation	Surveys questionnaire-based: - addressed to managers - addressed to employees	Management Employees (partly)
4.	Assess the company's innovation potential	Analyze the innovation factors and criteria Calculation of the scores of the innovation potential – by factors and overall Analysis of the disagreements and conflicts Benchmarking	Management Employees (partly)
5.	Feedback to the company management	Presentation of the results of the innovation potential assessment: scores of the innovation potential – by factors and overall; disagreements and conflicts; position – relative to the competition	Management
6.	Design the innovation balanced scorecard	Design a comprehensive set of indicators – to monitor the innovation process	Management
7.	Analyze possible solutions to improve the innovation capability	Explore and identify possible solutions Decide on the best solutions – according to the firm's strategy Decide on the intervention areas and methods	Top management
8.	Action planning	Design the set of measures / solutions to improve the innovation capability Planning of the associated actions	Top management
9.	Implementation of the action plan	Implement the plan (measures / solutions)	Project teams
10.	Progress evaluation	Re-calculation of the scores of the innovation potential – by factors and	Managers Employees (partly)

	overall Assess the efficiency of the solutions (effects noticed after 6 months at least) Resume the process and continue →

The authors have tested and improved the above model and methodology as well as the method to assess the firm's innovation potential (Alexe, 2009; Scarlat and Alexe, 2010; Alexe et al., 2010; Scarlat et al., 2010).

The focus of this paper is on the fourth stage – assessing the company's innovation potential, (Table 2) assuming that:

(i) this stage is just a component of the larger process of improving the firm's innovation capability – which assumes that the company innovates needs-based, innovation is part of its strategy; there is an innovation culture in place; the company continuously implements and learns out if its innovation actions (Lercher, 2008);

(ii) the factors and criteria presented in Table 2 are the result of thorough analysis aiming at identifying the significant elements that define the innovation potential.

Table 2: Innovation potential assessment – factors and criteria (Alexe, 2010).

No.	Factors	No. of criteria	Examples of criteria
1.	Strategy philosophy	15	Environment strategic analysis Forecast exercises Vision Mission statement does include innovation Innovation strategy New products marketing strategy Resources allocated for innovation …
2.	Company culture	12	Innovation culture Openness (outward) Conflict resolution Leadership style Risk orientation Attitude regarding the mistakes made …
3.	Organization	16	Hierarchy Flexible structures Delegation Decision autonomy Information flows Communication efficiency Decision making process Teamwork …
4.	Personnel	15	Training Promotion Change in organization Creative employees Financial motivation Non-financial motivation Focus on creative individuals

			…
5.	Technology	12	Technology know-how Patents Focus on technology change Methods to assess innovative ideas IT and dedicated software Benchmarking …
6.	Learning capability	16	Knowledge access Best practice Lessons learnt Involving clients in the learning process Involving suppliers in the learning process Sharing knowledge with others Relationships with consulting firms Relationships with R&D, HE institutions …
7.	Economic and financial performance	9	System to measure innovation activity System to register innovative ideas Indicators to measure innovation Innovation budget …
Total number of criteria		95	-

To note that each criterion implies actually a question or a set of questions; some examples follow:

(i) the "Environment strategic analysis" criterion should read as "Is the company running environment strategy-type analyses (on regular basis)?"

(ii) the "Knowledge access" criterion should read as "Do the company's employees have access to the company's knowledge database? Is there a system in place to disseminate the knowledge among employees?"

(iii) the "Indicators to measure innovation" criterion should read as "Does the company have a system of indicators to measure innovation and innovative activities, in place?" and so on.

The system is open in that sense that new criteria might be added if necessary; this might happen if a certain criterion generates more questions. For example: the criterion (ii) above.

Each factor is assessed criterion by criterion, as a percentage, independently, according to the IPAM (Innovation Potential Assessment Method) complex multi-interviewing procedure (Alexe, 2010). The results are summarized using an assessment fiche: Table 3 displays – as example – the matrix of a such fiche, used in the case of "Economic and financial performance" innovation factor.

Table 3: Innovation factors assessment fiche – "Economic and financial performance" factor: Calculation of the innovation potential score.

No.	**Innovation criteria**	**Evaluation scale, p [%]**				
		0	25	50	75	100
		No evidence	A few evidences	Partial evidences	Clear evidences	Complete evidences
		'Never happens'	'Sometimes happens'	'Balanced'	'Usually happens'	'Always happens'
1.	System to measure innovation activity					
2.	System to register innovative ideas					
3.	Indicators to measure innovation					
…						
9.	Innovation budget					
	Total number of answers	i = 1	i = 2	i = 3	i = 4	i = 5
		n_1	n_2	n_3	n_4	n_5
Score of the innovation potential				$S(F_7)$		

F_7 is the innovation factor number 7 (per Table 2).
$S(F_7)$ is the score of the innovation potential associated to the firm's "Economic and financial performance" – calculated as follows:

$$S(F_7) = (\Sigma_i n_i p_i) / (\Sigma_i n_i) \quad (1)$$

where:

$i = 1, 2, \ldots, 5$
n_i = number of answers associated to each percentage
p_i = percentage (i) i.e. 0%, 25%, ..., 100%
Σ_i = summation symbol, by i, from 1 to 5

A legitimate question (why the number of criteria is different – it varies from factor to factor) is addressed by using comparable measurement systems (as percentage). Consequently, the number of criteria is neither a limitation nor a limit; the design is open, new criteria might be added if considered necessary. However, deleting criteria is a huge mistake because disregarding a certain criterion (then a specific element related to innovation) is going to alter (lower) the score of the innovation potential.

A significant strength of the IPAM is the analysis of the divergences or even conflicts identified among opinions expressed by the interviewees (Table 4).

Table 4: Innovation factors assessment fiche – "Economic and financial performance" factor: Analysis of the conflicts in opinions (an example).

No.	Innovation criteria	Evaluation scale, p [%]				
		0	25	50	75	100
		No evidence	A few evidences	Partial evidences	Clear evidences	Complete evidences
		'Never happens'	'Sometimes happens'	'Balanced'	'Usually happens'	'Always happens'
1.	System to measure innovation activity	● ▲			♦	□
2.	System to register innovative ideas	● □ ▲ ♦				
3.	Indicators to measure innovation				▲	□ ● ♦
…						
9.	Innovation budget	▲	●	♦ □		
	Legend	● = respondent A; □ = respondent B; ▲ = respondent C; ♦ = respondent D; ...				

In principle, different cases are possible:

- strong disagreement (on the "system to measure innovation activity");
- strong agreement that the "system to register innovative ideas" is a weakness; here is a lot of room to improve the innovation potential;
- agreement that the "indicators to measure innovation" is a strength, an innovation advance;
- relatively limited disagreement (on the "innovation budget").

Each case or situation is managed by specific means; it should be underlined that the *innovation consultant plays a key-role.*

After assessing all factors, the firm's innovation potential is measured by the overall score of innovation potential S(IP):

$$S(IP) = \Sigma_j S(F_j) / 7 \qquad (2)$$

where:

$j = 1, 2, \ldots, 7$ (the total number of innovation factors considered)
F_j = innovation factor j
$S(F_j)$ = score of the innovation potential associated to the factor F_j
Σ_j = summation symbol, by j, from 1 to 7

The major critique addressed to this method is that the score itself – regardless how high or low is – does not offer decision support or image of the innovation potential of the company. For example: a company reporting a score like S(IP) = 49% is it good? Is it worse than another company with 55% innovation potential score? How innovative is our company overall?

DISTEH DECISION MODEL AND METHOD

It is extremely important for the company decision makers to have practical and operational tools to assess, analyze and rank their products according to their performance – compared with similar products of their competitors, which is, basically, to apply multi-criteria decision making models. The Neumann and Morgenstern's Utility Theory is probably the most

extensively used method to make multi-criteria decisions; since then (1944) lots of improvements were reported. Romanian school of industrial management made notable efforts in the area of developing new models to rank the industrial products according to their performance – compared with similar products of the competition.

Originally the DISTEH method was developed as decision model to assess the products' technical performance – as displaying some advantages compared to other decision methods (Scarlat 1980, 1981, 1987, 2000). The method was developed as a tool to assess the level of technical performance of products (goods or services) and technologies, within laboratories of Industrial Management Department from University "Politehnica" of Bucharest, Romania. The method was originally named "DISTEH" (Costake and Scarlat 1981, 18). The influence of time factor is considered first time by Costake and Scarlat (1985: 226, 233). DISTEH method was tested in a number of practical training, consulting and research circumstances and continuously improved; it is actually a multi-criteria decision-making model (Scarlat 2005c), and some of its major applications are addressed to products' competitiveness analysis (Scarlat 2004, 2005b, c), marketing pricing strategies (Scarlat 2004, 2005b), technology analysis (Scarlat 2004, 2005a) or technology prediction (Scarlat 2006). The flexibility of the method is tested in this case in a different area: assessing the innovation potential – considered a multi-criteria decision situation.

The basic DISTEH model: Absolute ranking

Assuming that any given decision option A_i (i = 1 to m; m = number of the available decision options) is characterized by a set of characteristics (criteria for assessing the innovation potential, in this case) C_j (j = 1 to n; n = number of criteria), one can define the performance matrix:

$$C = [c_{ij}] \tag{3}$$

where: c_{ij} is that value of the criterion C_j in the case of the option A_i.

In this case, the decision options correspond to the firms for which the innovation potential assessment is conducted. Then an important aspect is highlighted: *the assessment does have sense only in a larger context (the industry in which the targeted company is active). This also means that data about the firms active in this industry should be available and a consistent database should be developed. All these elements characterize a mature, well developed business environment.*

It is also understood that – for each company (i): a key-performance indicator (p_i) and the time of assessment (t_i) are known as well.

The purpose is to determine a unique value associated to each firm A_i ; this value is expected to describe the firm's innovation potential.
One can define an ideal firm (I) – in terms of its innovation potential, real or virtual – having the best criteria c_{Ij}, as follows:

$$c_{Ij} = max_i\,(c_{ij}) \quad \text{when criterion } C_j \text{ is to be as high as possible} \tag{4}$$
$$c_{Ij} = min_i\,(c_{ij}) \quad \text{when criterion } C_j \text{ is to be as low as possible} \tag{4'}$$

Note that (I) describes, generally, a virtual company. Its coordinates may vary in time but – if the analysis horizon is relatively short – the position of (I) is considered as time-stable (Scarlat 2000, 372).

The key-idea is that each company (i), either real or virtual, can be represented as a point in n-dimensional space. The closer the point is to (I), the better the firm – in terms of its innovation potential. Thus, it makes sense to define, for each company, *the innovation potential distance (ex technical distance) between the targeted firm and the ideal one,* as:

$$\overline{IP_i} = \sqrt{\sum_{j=1}^{n}\left(b_j \frac{c_{ij} - c_{Ij}}{c_{Ij}}\right)^2} \qquad (5)$$

where: b_j is associated with the importance of the criterion C_j; and b_j weights the criterion C_j ($0 < b_j < 1$).

The firms are ranked starting from the best one as innovation potential (minimum $\overline{IP}_i$). Note that the innovation potential distance is zero in the case of the ideal firm as innovation potential ($\overline{IP}_I = 0$). Bigger the $\overline{IP}_i$ value, lower the innovation potential of the company A_i and most probably its overall performance. In other words, for any given firm A_i (i = 1 to m), one might calculate a unique value associated to that firm $\overline{IP}_i$, value that allows the ranking of all the companies considered (starting with the best on the top).

Note that if only one company is assessed then the analysis makes sense as well because the ideal might be defined, by different techniques (e.g. benchmarking-type).

DISTEH model: Relative ranking

The DISTEH method can also apply when the decision maker needs to select not the absolutely best firm but the *relatively best firm*, in a similar manner (Scarlat 2000, 372-373). The formula is slightly different (6): only "D" ("Desired") replaces "I" ("Ideal").

$$\overline{IP_{Di}} = \sqrt{\sum_{j=1}^{n}\left(b_j \frac{c_{ij} - c_{Dj}}{c_{Dj}}\right)^2} \qquad (6)$$

The "desired" firm does not have necessarily the best features. *The coordinates of the D point/firm are decided usually by the customer, not by the decision maker.*

Self-calculation of the weight coefficients

When necessary and/or required, all decision-making methods consider the weight coefficients (b_j). And almost all methods estimate b_j values subjectively. Only when those values are the result of well-conducted (marketing) surveys, the decision making process is fair. Most methods assess the weight coefficients (b_j), subjectively. A much simpler approach is used by DISTEH method: each of the weight coefficients b_j is calculated based

on dependency reported by each of the $P(C_j)$ linear regression curves (Scarlat 1987, 285, 287):

$$m_j = \frac{m\sum_{i=1}^{m} c_{ij} p_i - \sum_{i=1}^{m} c_{ij} \sum_{i=1}^{m} p_i}{m\sum_{i=1}^{m} c_{ij}^2 - \left(\sum_{i=1}^{m} c_{ij}\right)^2} \tag{7}$$

and

$$b_j = \left| \frac{m_j}{\sum_{j=1}^{n} m_j} \right| \tag{8}$$

where:

$P = [p_i]$ is the vector of firm performance
$C_j = [c_{ij}]$ is the vector of values of the criterion C_j (j = 1 to n) for all the firms (i = 1 to m).
The signum of m_j has its own significance: "+" identifies "high features" (4) and "-" points "low features" (4').

Identifying the *Critical Characteristic*

The *Critical Characteristic (CC)* defines that criterion, which worsens the firm's innovation potential (makes the corresponding value $\overline{IP}_i$ too high). CC could be easily identified - as corresponding to:

$$\max_j \left\{ \left(b_j \frac{c_{ij} - c_{Ij}}{c_{Ij}} \right)^2 \right\} \tag{9}$$

respectively

$$\max_j \left\{ \left(b_j \frac{c_{ij} - c_{Dj}}{c_{Dj}} \right)^2 \right\} \tag{9'}$$

Once identified, CC must be improved: "Improving the CC" would be the major task for the consulting team working with the target company top management and R&D department. The improving process is continuous: when CC completes its "improving potential", the next-in-line criterion follows.

Usually, the ranking depends on the weights. However, there are cases – both in theory and practice – when the ranking of two options remains unchanged, for all the possible values of their respective weights ($0 \le b_j \le 1$) or, at least, for large variation intervals. Such analysis is presented in (Scarlat 1981).

To conclude, the DISTEH method is a useful tool to assess the firms' innovation potential and rank them accordingly, objectively. Based on the same model, the firm's overall

innovation capability can be improved by setting research priorities – corresponding to the most sensitive criteria.

CASE STUDY: THE COMPANY IMG. RESULTS AND DISCUSSION

The applicability of the DISTEH method for assessing the innovation potential of companies was tested in the case of a Romanian company active in media industry (IMG) which was already analyzed in terms of its innovation capability, and its innovation potential was already assessed by a 'control' method (IPAM) – as previously described by formulas (1) and (2).

It is worthy to mention that both methods were developed by the authors (IPAM by Alexe and DISTEH by Scarlat), first as a dedicated method, second as a multi-purpose decision tool. Just anecdotally: while IPAM is an image of incremental innovation, the use of DISTEH for assessing the innovation potential corresponds to a disruptive innovation.

Under same hypotheses (assuming that the factors and criteria presented in Table 2 are the result of thorough analysis aiming at identifying the significant elements that define the innovation potential; and based on the same results of the analysis – same consequences per each criterion) the comparative results are depicted in Table 5. The assessment of the firm's innovation potential was a part of the more comprehensive analysis of the firm's innovation capability which was conducted in 2010-2011.

Table 5: Model for assessing and continuously improving the firm's innovation capability.

No.	Innovation factors	IPAM [%]	DISTEH	
			Absolute[1]	Relative[2]
1.	Strategy philosophy	58.88 (V)[3]	0.0587 (V)	0.0445 (V)
2.	Company culture	63.88 (VII)	0.0516 (VII)	0.0516 (IV)
3.	Organization	59.37 (VI)	0.0580 (VI)	0.0295 (VII)
4.	Personnel	40.00 (II)	0.0857 (II)	0.0857 (II)
5.	Technology	45.19 (III)	0.0783 (III)	0.0426 (VI)
6.	Learning capability	54.16 (IV)	0.0655 (IV)	0.0655 (III)
7.	Econo-finance performance	18.51 (I)	0.1164 (I)	0.1164 (I)
Overall score for innovation potential		**48.57**	**0.2019**	**0.1803**

[1] To the ideal [100%; 100%; 100%; 100%; 100%; 100%; 100%]

[2] Relative to a desirable profile of innovation potential [90%; 100%; 80%; 100%; 75%; 100%; 100%]

[3] The priority ranks are given in brackets (parenthesis)

Both methods offer the same results – in terms of priority ranking: both point at "economic and financial performance" as the factor that damage the firm's innovation potential the most (only 18.51% innovation potential / 0.1164 maximum distance from the ideal point of innovation potential). And the "company culture" is the most advanced innovation factor for the company IMG.

The results in both methods are non-dimensional. However, it should be noted that DISTEH values are distances to the ideal point of innovation potential: lower the value, shorter the distance, better – see formula (5).

Both methods allow watching the dynamics of the innovation potential (how the score evolves in time – calculated periodically).

Results are presented in case of non-weighted criteria and factors. The results are not changing significantly in the case of considering weighted criteria and/or factors. However, there are twofold advantages of the DISTEH method in this respect:

- it allows the objective self-calculation of the weights;
- it allows direct correlation between firm's innovation criteria, factors, and potential – on one hand – and firm's key-performance indicators.

The latter is actually a direction of further research.

The higher potential of the DISTEH method is evident when DISTEH is relatively calculated (6). The relative point is the desired level of innovation potential factors, to be reached in the future. Those target levels (which might differ from 100%) are established by benchmarking methods, using adequate database. In the case of the company IMG analysis, a top competitor was surveyed and its levels of innovation potential factors assessed accordingly. The results are changing in that sense of priority setting: some of the innovation potential factors are unchanged as priority (I and II) while others are changing; the IMG's "strategy philosophy" keeps its rank (V) just by accident.

The implications for the IMG top management are of substantial importance: as priorities are changing, the actions are different – following to the ranking determined by calculating the relative technical distance. And so are the associated cost, and the expected efficiency of the efforts to improve the IMG's innovation capability. Currently, this process is in full progress.

IPAM has the advantage of simplicity and directness. DISTEH is more sophisticated as the calculus is little bit more complex. The trade-off is that DISTEH has a higher potential offering more information for the firm's decision makers.

CONCLUSIONS

The firm's innovation potential assessment is a necessary exercise – part of the firm's process to improve its innovation capability, and – supposedly – its competitiveness and overall performance.

Assuming that the analysis of the innovation factors and inventory of the innovation criteria is fairly conducted, the need for improving the firms' innovation capability could be satisfied using IPAM and DISTEH methods for assessing the firm's innovation potential.

The use of the DISTEH model and method for assessing the innovation potential was validated – its outcomes resonating to the IPAM results.

Both methods offer reliable and coherent results, and both could be used for examining companies' dynamics in terms of innovation potential. However, IPAM is more intuitive (as percentage is calculated), more direct and simple that the more complex DISTEH, although the latter has a higher potential offering more information for the firm's decision makers.

In any case, there are critical prerequisites: quality consulting services, quality databases – by industry and own firm, which allow benchmarking studies, dynamics analyses and alike as reliable background for sound strategic decisions.

When the target is specifically set by benchmarking techniques or other reasons-based, then the assessment of the innovation potential, and the actions to improve the company's innovation capability must be conducted by use of DISTEH and calculating the relative technical distance of the innovation potential.

The IMG case study (assessment of the innovation potential of a Romanian company active in the media industry) reveals important implications for firms' top management: choosing the appropriate method (as DISTEH associated to benchmarking techniques to calculate the relative technical distance) impacts the firm's priorities, actions, and – consequently – the associated cost, and the expected efficiency of the firm's efforts to improve its innovation capability.

The results of the experiment prove to be useful for the firm's managers who have made decisions to enhance its innovation potential, innovation capability and, therefore, the firm's competitiveness. The implications are of high importance for practitioners (entrepreneurs and managers) as well as for the researchers and academics interested in developing tools to assess the firm's innovation potential, continuously.

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ASSESSING THE INNOVATIVENESS OF THE TAIWANESE FOOD INDUSTRY WITH DEA

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ABSTRACT

The ability of companies to meet consumer expectations depends deeply on their ability to innovate and deliver new products at competitive prices. Especially in the low and medium technology industries there is still a gap in the area of innovativeness studies. This research was designed to determine the key innovativeness factors for the Taiwanese food industry and uses a questionnaire to collect data about its innovativeness. The Data Envelopment Analysis (DEA) shows which products/brands, among our sample group, are the most innovative and which are the least. Strategies how to improve the innovative ability are then proposed by assessing the differences between the best and the worst companies, also, taking the size of a company into consideration. Our study contributes by finding a set of factors of innovative ability for the Taiwanese food industry, determining outstanding examples from the researched industry that can be used as a benchmarks, and finally, it proposes innovativeness improvement strategies to the food industry in Taiwan, considering the size of the company.

Keywords: innovativeness, food industry, DEA, Taiwan

INTRODUCTION

Nowadays, innovation is one of the key drivers for company's competitiveness and success, in any industry (OECD, 2005; O'Regan et al., 2006). It is a popular topic for research especially in the high-technology and IT industries that are heavily dependent on Research and Development activities (Armbruster et al., 2008). No wonder that a common thinking is that innovation equals to R&D activities, however this is not a case, especially in less technology-oriented industries – low and medium technology industries (LMT industries). There is also less focus in the innovation literature on the Small and Medium Enterprises' (SMEs) innovativeness ability, as they rarely can afford the expensive R&D activities. However, in latest years it was acknowledged that SMEs also have potential to innovate (OECD, 2005), therefore this article will compare the findings for small, medium and large food industry companies in Taiwan.

Nonetheless, an important question is how to asses innovativeness ability (or innovativeness, both terms used interchangeably in this paper) of a company? Therefore, the measurement of innovation results or innovativeness of companies, products, or just certain innovation projects is the focus of our paper, especially for the food industry Taiwan.

The study chooses Taiwan as the research base, because of the strong innovation culture that exists in this country due to its high development and mature high-technology sector. The researcher believes the results can be useful for application in other countries with similar development level, or used as a benchmark by developing countries.

LITERATURE REVIEW

Innovation and Innovativeness

Firstly it is important to understand what innovation is and what opportunities it brings to businesses, as it is agreed that it is critical for achieving the competitive advantage (Hsieh et al., 2009). According to Schumpeter (1934) innovation is considered to be a complex phenomenon, which includes technical (new products and production methods) and non-technical aspects (new markets and forms of organization).

Then, Myers and Marquis' (1969) definition describes innovation as follows: '*Innovation' is not a single action but a total process of interrelated sub processes. It is not just the conception of a new idea, nor the invention of a new device, not the development of a new market. The process is all of these things acting in an integrated fashion*. This definition combines all kinds of innovations into one broad term and therefore can be used in researches aiming at innovation measurements.

In the 21st century, more studies broadened the concept of innovation to all other business fields, including Low and Medium Technology Industries (LMT) and also Small and Medium Enterprises (SMEs), that was earlier rather neglected by innovation researchers (OECD, 2005). "Oslo Manual - Guidelines for Collecting and Interpreting Innovation Data" published by the OECD (the Organization of Economic Co-operation and Development) and European Commission defines four basic kinds of innovations: Product, Process, Organizational, and Marketing Innovation (OECD, 2005).

On the other hand, according to Garcia and Calantone (2002) innovativeness is the most frequently used measure for a degree of innovation's "newness", and so a highly innovative product or process would be one of a high degree of newness. However, product innovativeness is not equal to firm's innovativeness, and it is the second that we find more interesting, as it can help to evaluate companies' positions within the industry. Ettile et al. (1984) defined organizational innovativeness as the tendency for the firm to innovate or develop new products, while Rogers (1995) called it also a tendency to adopt innovations. In these both cases we can see that the newness of product does not influence the innovativeness of the organization. Still, there is many innovation strategies that companies can choose from and the problem is how then these companies can be compared.

Food Industry

The study can only focus on a certain industries since innovation processes differ greatly from industry to industry in development, rate of technological change, linkages and access to knowledge, as well as organizational structures and institutional factors (Malerba, 2005; OECD, 2005). Prior researches usually focus on high-technology industries (3C, biotechnology,

pharmaceutical industries), and only few in agriculture or food industries (Fortuin et al., 2007). Some of these are: Pannekoek, Van Kooten, Kemp and Omta (2005) - innovation projects in greenhouse horticulture, Batterink, Wubben and Omta (2006) - agrifood industry, and Fortuin et al. (2007) - innovation projects in food industry.

Food industry is a LMT industry, and more recent studies are starting to research innovation among LMT firms (Heidenreich, 2009; Robertson et al., 2009) acknowledging their important role in building global innovativeness. Generally, the innovation ability of the LMT firms may be underestimated since they buy their technological expertise, formally or informally, from outside, rather than develop it inside the organizations (Hirsch-Kreinsen et al., 2006).

In each country, food industry is one that provides basic, daily products to the national market. In our research, we want to use a comprehensive but simple definition of food industry, proposed by the UK's Food Standard Agency (2009): *the whole food industry – from farming and food production, packaging and distribution, to retail and catering*. It is comprehensive, however focuses on the companies, in which food products, or for which food handling, is crucial and influences the way these businesses run.

Innovativeness Factors for Taiwanese Food Industry

We gathered and organized in five dimensions the factors having an influence on the Taiwanese food: Product, Process, Organizational, Marketing, and Eco-Innovation (see Table 1).

Table 1: Innovation dimensions and factors for Taiwanese food industry.

Product	**Process**	**Organizational**	**Marketing**	**Eco-Innovation**
1. product superiority, 2. market potential, 3. competitive pressure, 4. project--company fit, 5. project resources	1. technological skills and know-how, 2. R&D activities	1. strategy and innovation culture, 2. communication and cooperation, 3. business groups, 4. new managerial methods	1. advertising and promotion	1. Eco-innovation

The first dimension is 'Product Innovation' and it consists of 5 factors. They are: product superiority (is the product being superior to competing products; is it the first in the market; does it have higher quality than competitors; does it offer new applications to customers; etc.), market potential (the monetary value of the existing or potential market; is the market growing; do the potential customers have a great need for this product; will the customers definitely use the product; will it contribute to the competitive advantage of the firm), competitive pressure (is the market highly competitive; number of active competitors; price competition wars), project-company fit (the nature of the production process, distribution system and/or type of sales force; customers and competitors and their newness to the firm), project resources (company's financial and production resources; management and engineering skills adequateness for the project; marketing research skills; sales and distribution resources adequateness for the project) (Fortuin et al., 2007).

The second dimension 'Process Innovation' includes two factors: technological skills and know-how, as well as R&D activities. Both those factors have been drawn in directly from the 3rd edition of the Oslo Manual. Technological skills and know-how concern about the technological skills of the workforce of the company, technological resources, as well as the way company acquires external knowledge in connection to development and implementation of new innovations. Then, R&D activities include two aspects, one being the basic research, the second one being the new product or process development and testing (OECD, 2005).

Even though some studies were mentioning the non-technological aspects of innovation much earlier, it was the beginning of the 21st century when academic world fully acknowledged and appreciated the importance of organizational innovations (OECD, 2005). Examples of other studies using organizational innovation in their researches are: Greenan, 2003; Rejeb et al., 2008; Armbruster et al., 2008. The 'Organizational Innovation' dimension includes following factors: Strategy and innovation culture - one of the key factors influencing product innovation management (Cormican and O'Sullivan, 2004) that should specify market niches as targets for the company's focus and formalize the necessary structures for implementation; Communication and cooperation (good communication within the team, management commitment, clear performance requirements, understanding the project problems by the employees, etc.) (Fortuin et al., 2007); New managerial methods (organisational changes implemented in response to a new managerial strategy that represent the first implementation of a new organisational method) (OECD, 2005); Business groups (relationships that the companies establish with other organizations, or within the company, to facilitate their capabilities through synergy effect). In Taiwan, the business groups are called 'Jituanqiye' (集團企業), and are specific kind of business models distinct from traditional enterprises. They consist of legally independent companies that are however controlled by only one owner. These independent companies have to meet their own independent objectives as well as the whole business group's goals. The group factors influencing company's innovation include group affiliation, diversification, inside ownership and family ties (Hsieh et al., 2009),

The OECD also included the marketing into their innovation definition arguing that nowadays firms allocate large amounts of resources into market research and development on new marketing channels, including targeting new markets or market segments as well as coming up with new advertising/promotion ways (OECD, 2005). This paper use one factor called 'Advertising and promotion' to represent this dimension, based on the marketing innovations concepts used in the Oslo Manual and the Fortuin et al. study (OECD, 2005; Fortuin et al., 2007). The marketing innovations' goal is to better address customer needs, open up new market, or position firm's product on the market in a new way, with the objective of increasing the firm's sales, which can be achieved by better communication with the customer, which is done by the advertising and promotional activities.

The final innovation dimension incorporated into this paper is called 'Eco-Innovation'. It was not included in neither the Oslo Manual, nor the Fortuin et al. (2007) study, however the literature review of articles from last few years revealed that environmental issues are growing in importance in every area and every industry and should not be left out, especially that there is still huge room for innovations to create more environmentally

friendly products. Especially when food products are considered, the eco factors are often perceived as safety and healthy factors by customers, and therefore there is a pressure from consumers onto the industries to innovate their product and processes in the 'green' way. Rennings (2000) argues that eco-innovation should be included in the common understanding of the concept of innovation. Some of his arguments are: the demand for drastic reductions of environmental burdens, innovation is expected to offset burdens and costs induced by the environmental regulations, new types of vehicles, renewable energy systems or corresponding infrastructure often need at least a decade for invention, adaptation and diffusion, long-term sustainability goals cannot be met by progress in environmental technology and must be supplemented by corresponding lifestyles and institutional changes, environmentally-friendly processes or products are already a part of everyday life in majority of firms so managing eco-innovation is increasingly important issue for them, and finally it is crucial to define key determinants and success factors of innovation processes for sustainability. We use the definition of 'eco-innovation' propsoed by Klemmer et al. (1999): *Eco-innovations are all measures of relevant actors (firms, politicians, unions, associations, churches, private households) which:*
1. develop new ideas, behavior, products and processes, apply or introduce them and
2. which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets.

This paper uses just one combined factor names same as the dimension eco-innovation that combines four eco-innovation concepts together, these concepts are: Land and water resources management (part of the agriculture sustainability practices) (Wall and Smit, 2005), Environmental technologies (Rennings, 2000; Freeman, 1996), Green Supply Chain Management (reducing material intensity, reducing energy intensity, reducing dispersion of toxic substances, enhancing recyclability, maximizing use of renewables, extending product durability, 'green' certification, organic products) (European Environment Agency, 2006; Desimone and Popoff, 1997), Pollution management (air pollutions, noise pollutions, and recyclability of materials and products) (Fortuin et al., 2007; Desimone and Popoff, 1997; European Environment Agency, 2006).

RESEARCH METHODOLOGY

This study follows the steps of prior innovation studies, which have already been well established in the literature, and uses a questionnaire survey for data collection. Most importantly, this research chose to use the questionnaire as the main data collection tool in accordance with the Fortuin et al. (2007) research.

Based on the literature review, we incorporated the five innovation dimensions as five parts of the questionnaire, and adding the company's data as the last part of the survey. Basically the questionnaire used 7 points Likert's scale questions and statements (from 1 as 'strongly disagree', to 7 as 'strongly agree.'), similarly to other studies, such as the Fortuin et al. (2007) survey. Only few open-ended questions were used, asking for short, numerical answer about the company's chosen most successful product/product line/brand, and a few multiple-choice questions for numerical data, that asked about percentage data (e.g. % of the annual budget reserved for new product development). These kinds of questions were designed to assess numerical data about the company, for example asking about number of employees

working on new product development projects.

The distribution of the questionnaire had place in between 20th and 26th March 2010, by sending out the forms via e-mail to various Taiwanese food industry companies. In total 91 filled questionnaires came back in between 20th March and 30th April 2010. After the preliminary screening of the questionnaires forms and combining samples for the same food product line/brand, 46 usable samples were viable for the data analysis. According to Ramanathan (2003), the sample size for a DEA analysis need to be at least 2 or 3 times larger than the sum of the number of inputs and outputs, which is the case of this study (see Table 1). We determined 13 of such factors, which mean the sample size of 46 is representative enough to draw conclusions.

Data Envelopment Analysis

Since one of the main objectives of this study is to observe the innovativeness of the food industry in Taiwan and create the industry's benchmark and way to compare companies' innovative ability, Data Envelopment Analysis (DEA) is used in this research for the data analysis.

DEA is a method used to evaluate the efficiency among a number of organizations (or some kind of independent units) (Anderson, 1996). It is an extreme point method that compares these units, in this case food companies in Taiwan, with the “best” ones, or in our case the most innovative ones. In the literature, these units are usually called decision making units (DMUs), but for simplicity and clarity, this study refers to them as 'products', 'product lines', 'product categories' or 'brands.' The fact that the efficiencies estimated in DEA are relative to the best performing companies is what makes DEA different from other analysis tools, which usually are concerned with finding the theoretical optimum. The best-performing unit is assigned with an efficiency score of unity '1' or 100%, and performance of other companies, then, varies between 0 and 100% relative to this best performance (Ramanathan, 2003). In the case of this research, the comparison between different companies' products can be made because all of them are a part of the same environment - the Taiwanese food industry. DEA was already used in innovativeness studies, however mostly they have focused on technological innovations, such as Guan et al. (2006) and Diaz-Balteiro et al. (2006).

The innovativeness is an effect of certain inputs and can be captured as a certain output. According to Hussain and Jones (2009), an input *is any resource used by a unit to produce its outputs (products or services)*, including resources that are not a product *but are an attribute of the environment in which the units operate*. Inputs can be controlled or uncontrolled by the unit. An uncontrollable input is one *over which the unit's management does not have control and hence cannot alter its level of use or production*. Whereas outputs *are the products (goods, services or other outcome) which result from the processing and consumption of inputs (resources)*. They can be *physical goods or services or a measure of how effectively a unit has achieved its goals.* Therefore, this study uses the previously determined factors (see Table 1) as inputs, with only one exception, product superiority factor, being used as an output. It is one of the strengths of DEA that the number of inputs and outputs is not restricted, there only needs to be at least one input and one output determined to perform the analysis.

Having the DEA results, the ranking of the Taiwanese food industry innovativeness, we can assess the innovativeness situation among Taiwanese food industry firms and help the non-perfect companies to improve to the level of the fully efficient (innovative) companies. The basic measurement concept of the DEA is the ratio of total outputs to total inputs:

Efficiency = Output / Input

The specialist software The Frontier Analyst® software (developed by the Banxia Frontier Analyst Professional) is the one used in this research to perform the calculation and comparison between the product lines/categories. It requires specifying if the inputs are controllable or not, and we have only set up two factors, market potential and competitive pressure, as uncontrollable factors. These two inputs variables are depending on the company's competitive environment and market, and therefore it is only logical to set them as uncontrollable inputs. Also, we have chosen to use the Mac Out optimization mode in the analysis, which is output maximization mode. It is the DEA mode adopted in which the analysis tries to maximize the outputs produced for a fixed amount of inputs (Hussain and Jones, 2009), since in our study the high level of innovativeness is an output, therefore we rather find out the good benchmark of how to reach the high innovation ability than focus on the minimization strategies for its input variables (resources). Finally, in the analysis we used the BCC ratio model, that is *used when a variable returns to scale relationship is assumed between inputs and outputs* (Banxia Software Ltd., 2010). If the increases are not proportional, it means there is no linear relationship between inputs and outputs. In such case, the BCC ratio model is suggested to be used.

RESULTS

This study has received 91 questionnaire responses, combined into 46 samples, from 18 different food industry companies. In some cases, there was more than one sample (product line/brand) representing a company. An example can be a big retail chain store company, that provided the study with total of three samples, one as for the retail service, one for their own branded coffee product line and one for their private labeled food. Table 2 below, summarizes the samples source.

Table 2: Samples sources.

Company	**Products/Services (code, numbers of responses for each sample)**	**Number of samples ***	**No. of responses****
Winery	ice-creams (A, 3), cookies (B, 2), wine egg (C, 4), wine (D, 1), sake (E, 1), wine 1 (F, 1), wine 2 (G, 1), beer (H, 1), Chinese style wine (I, 1), strong wine (J, 1), vodka (K, 1), whiskey (L, 1), beer 1 (M, 1), healthy food (N, 1), frozen wine egg (O, 1);	15	21
Honey Farm	honey (P, 1), honey wine (R, 1), propolis (S, 1);	3	3
Convenience stores chain	convenience store (T, 8), coffee (U, 1), private brand (V, 1)	3	10
Noodles company	fried flavored noodles (W, 1), instant noodles (X, 6), vegetarian instant noodles (Y, 4), instant noodles 1 (Z, 3), instant noodles 2 (BA, 1), snacks (BB, 2), flavored noodles (BC, 1), instant noodles 3 (BF, 3), functional drink (BG, 2)	9	23
Juice company	fruit juice (BD, 1), vegetable juice (BE, 1)	2	2

Food company A	food products (BH, 1)	1	1
Food processing company	aquatic products (BI, 1)	1	1
Fishery company	frozen sea food (BJ, 1)	1	1
Steak house restaurant	Steaks (BK, 1)	1	1
Supermarket	supermarket (BL, 1)	1	1
Functional food and tea	functional food (BM, 1)	1	1
Food company B	long preserved food (BN, 1)	1	1
Seafood company	sea food (BO, 1)	1	1
Food company C	instant noodles 4 (BP, 1)	1	1
Food company D	breakfast product (BR, 1)	1	1
Natural Healthy food	natural healthy food (BS, 1)	1	1
Food packaging	food packaging (BT, 1)	1	1
Beverages company	beverages (BU, 1)	1	1
Dairy products company	milk (BV, 1)	1	1
TOTAL	46	46	73

*Note: Sample is a sum of responses for a certain product line/brand in a company.
**Note: Responses are number of questionnaires received for each sample. Some product categories got more than one response, therefore the number of responses may be higher than number of samples.

To summarize the respondents characteristics, we can say the sample group used in this study is quite diversified, which is an advantage in the case of this research, as it can represent the innovative ability of different kind of companies in the Taiwanese food industry, especially considering their different sizes. Also the respondents' experience background is quite varied, and it is not only R&D and product development background as in traditional innovation studies, which should allow us to observe the innovation in companies not only through the technological dimension, and see if the innovativeness culture of the company clearly throughout the whole organization. The definition of food industry that was chosen in this study was actually a guideline for choosing the sample group, and in the end companies that did not match the definition were excluded from the analysis. In summary, we think the sample group represents the Taiwanese food industry well with its diversity in specializations, size and market experience, which allows us to draw conclusions about the benchmark for the industry in Taiwan.

DEA Results

The general results are firstly presented as a list of the samples and their efficiency. However, one needs to remember that 'efficiency' in the DEA means getting the optimal level of outputs with the optimal level of inputs, in comparison to other peers used in the analysis, so in our case it means that the higher product superiority and product novelty, that represents the innovativeness of the company, the better efficiency can be achieved by the company (Max Out mode). Among our sample group, only 5 samples were determined as inefficient (efficiency below 100%), and the overall results are presented below in Table 3.

Table 3: Sample group efficiency scores.

Sample code*	**Efficiency**
A, C, D, E, F, G, H, I, J, K, L, M, N, O, P, R, S, U, W, X, Y, BA, BC, BD, BE, BG, BH, BI, BJ, BK, BL, BM, BN, BO, BP, BR, BS, BT	100%
BF	99.23%
V	99.07%
BB	92.84%
Z	91.22%
T	90.53%
BV	87.83%
B	87.70%
BU	84.20%

*Note: For the analysis convenience, the samples were coded with the roman alphabet symbols from A to Z, and then BA to BV.

Therefore, only 17.39% of the studied sample was found inefficient. Generally it is true that the Taiwanese food industry is quite innovative, but it also means that the level of innovativeness among the industry is homogenous. Therefore, in peer comparison (as in DEA), most of the sampled products/brands were determined to be as innovative as the others in the sample group, hence the high 100% efficiency results.

Even though 38 of the analysis units were defined as 100% efficient, Frontier Analyst® gives us a tool to choose the best examples among this group. By checking the Reference Set Frequency, the researcher can see how many times a certain efficient unit (product/brand) appeared in the inefficient unit's reference set. Generally, the higher the frequency, the more the efficient unit is an example of good performance, and that is why it was chosen as peer more often for comparison (Hussain and Jones, 2009). In our analysis the highest set frequency was achieved by following samples: I (Chinese style wine, middle sized company), BL (retail supermarket, large company), and BG (functional drink, middle sized company) 5 times, U (coffee, large company) and BD (fruit juice, middle sized company) 4 times, BS (natural healthy food, small sized company), BM (functional food, middle sized company), BI (aquatic products, small sized company) 3 times.

The Frontier Analyst® also calculates the “potential improvements” for each unit. It is presented as the percentage change in each input variable (or output variable) that is necessary for the unit to become 100% efficient. It can have positive or negative value, indicating if the inputs or outputs are too big or too small, to reach the optimal level. The potential improvement is calculated based on the actual score and the target score (value of input or output that should be achievable by the sample, and which would assure it the 100% efficiency) set for each sample. For example, if the suggested improvement is -2.83% for input I1, it means that to reach 100% efficiency score for sample BF, the scores for factor I1 should be decreased by 2.83%. The potential improvements with the highest value are put in bold. Below the results for the most inefficient cases are presented. But first we presents the codes for each of the factors used in the analysis and presentation of the results below: O1 (Product Superiority, the only output in our analysis), I1 Market Potential, I2 Competitive Pressure, I3 Project-Company Fit, I4 Project Resources, I5 Technological Skills and Know How, I6 R&D Activities, I7 Strategy and Innovative Culture, I8 Communication and Cooperation, I9 Business Groups, I10 New Managerial Methods, I11 Advertising and Promotion, I12 Eco-Innovation (also, see Table 1).

1. Instant noodles 3 (BF) - efficiency 99.23%. DEA suggested potential improvements: O1 0.77%, I1 -2.83%, I5 -0.76%, I8 -1.38%, **I10 -6.18%**, **I11 -13.99%**. In this case the focus should be put on improving the New Managerial Methods (I10) and Advertising and Promotion (I11). It can be observed that all improvements are negative, which means that now, the company puts too much efforts in those factors to improve their snacks (BB) innovativeness, and could achieve same output level (a level similar to other companies in the industry, which are here defined as 100% efficient) with lower levels of input factors, so with less effort.

2. Convenience store's private brand (V) - efficiency 99.07% Suggested potential improvements: O1 0.94%, I1 -11.50%, **I3 -18.69%**, **I4 -22.96%,** I5 -8.41%, I8 -10.9%, **I9 -25.69%,** I10 -11.66%, I11 -11.86%. Similar as above, the company puts too much effort in certain areas, such as: Project-Company Fit (I3), Project Resources (I4) and Business Groups (I9).

3. The snacks (BB) - efficiency 92.84%. Suggested potential improvements: O1 7.71%, I1 -4.33%, I4 -3.88%, **I8 -13.07%**, **I9 -19.9%, I11 -10.76%**. In this case, again, the company puts too much of its resources into Communication and Cooperation (I8), Business Groups (I9) and Advertising and Promotion (I11).

4. Instant noodles 1 (Z) - efficiency 91.22%. Suggested potential improvements: O1 9.63%, I1 -9.25%, I3 -6.35%, **I8 -14.23%**, I9 -8.52%, I10 -6.08%, **I11 -15.94%**, **I12 -11.78%**. As in samples above, the noodle company puts too much effort in Communication and Cooperation (I8), Advertising and Promotion (I11) and Eco-Innovation (I12).

5. Convenience store, retail (T) - efficiency 90.53%. Suggested potential improvements: O1 10.46%, **I1 -12.26%,** I3 -11.87%, **I4 -15.96%**, I8 -1.87%, I9 -9.26%, I11 -1.41%, **I11 -14.74%**. Again, the convenience store put too much effort in following factors: Project Resources (I4), Advertising and Promotion (I11), and also Market Potential (I1).

6. Milk (BV) - efficiency 87.83%. Suggested potential improvements: **O1 13.85%**, **I3 -13.65%**, I5 -0.69%, **I6 -15.14%**, I7 -1.0%, I8 -1.61%, **I9 -15.14%**, I10 -5.72%, I11 -6.16%. In this case, the output factor, Product Superiority, has to be especially increased, suggesting maybe the product's innovativeness is not strong enough. Other than that too much effort is put into following areas: Project-Company Fit (I3), R&D Activities (I6) , and Business Groups (I9).

7. Cookies (B) - efficiency 87.70%. Suggested potential improvements: **O1 14.02%**, I2 -7.42%, **I4 -20.52%**, I7 -6.50%, **I9 -25.05%**, I10 -1.01%, I11 -4.59% Similarly as above, the output level is too low and should be increased (Product Superiority). Other than that, too much effort is used in Project Resources (I4) and Business Groups (I9) factors.

8. Beverages (BU) - efficiency 84.20%. Suggested potential improvements: **O1 18.76%**, I2 -3.65%, I4 -6.73%, I5 -8.20%, **I6 -22.35%**, **I8 -30.55%**, **I10 -22.80%**, I11 -15.96%. In the least efficient case, the output levels should also be increased, and the efforts used in R&D Activities (I6), Communication and Cooperation (I8), and New Managerial Methods

(I10) should be decreased.

Generally there are two ways for the inefficient companies to improve their innovativeness. The first one, is to keep the current high input levels (high effort in the certain innovativeness factors) and at the same time trying to increase the output (through better implementation of the inputs). Or, the second option is to decrease the efforts where the DEA analysis suggested to (negative potential improvements). In that case, however, the management needs to be careful, not to lower the input levels too much, and still ensure the same output level.

Improvement Strategies

The interest in SMEs among the academics is growing, as is the number of small firms all around the world, and also in Taiwan (Taiwan SME, 2010). We use the United States division of the companies according to their size, according to which, the SOHO (small office/ home office) size is up to 10 people, the small company is one with up to 100 employees, and a medium sized company with up to 500 employees (U.S. Census Bureau, 2010).

Below we present the most innovative and the least innovative companies according to their size. The most innovative companies, are those who were used as peer references in the analysis (see reference set analysis results above) and the least innovative one are those who received efficiency scores lower than 100%. Small sized companies were not found either among the most or the least innovative groups.

1. Large companies (employees number, % efficiency): BL Supermarket (5000, 100%), U Convenience store's coffee (1500, 100%), V Convenience store's private brand (1500, 99.07%), T Convenience store retail (1500, 90.53%), BV Milk (2000, 87.83%).
2. Medium companies (employees number, % efficiency): I Chinese style wine (196, 100%), BG Functional food (395, 100%), BD Fruit juice (400, 100%), BF Instant noodles 3 (395, 99.23%), BB Snacks (395, 92.84%), Z Instant noodles 1 (395, 91.22%), B Cookies (196, 87.70%), BU Beverages (300, 84.20%).

Based on the company size and comparison of the DEA analysis results some improvement strategies for better innovativeness are proposed:

a) Small companies (up to 100 employees) - all of the small food companies participating in the study were found to be 100% efficient in their innovativeness. It proves that small size does not have to be an obstacle in innovating, and that it is worth researching the way small companies innovate. All of the samples among this group got high overall scores in the questionnaire for the inputs and outputs, which can be understood that they both input a lot of effort and resources into innovativeness, treating innovation as important part of their business strategy, but also they are implementing it efficiently, so they can reach relatively higher output levels. However, none of the small companies was identified as the best example among the efficient group by the DEA analysis, which still leaves room for improvements. Small companies were found to be most innovative in the organizational, marketing and eco-innovation dimension, as compared to medium and large firms, they usually does not have enough financial resources for pursuing the more technological

innovations.

It is worth noticing that especially eco-innovations might be a good opportunity for small food companies, as the philosophy of the organic production is to produce in small scale, for local needs only. Therefore what before was a weakness, now can become an advantage for the small sized firms. However, it is very important to market eco-products effectively, and therefore the marketing innovations also should play an important role in company's strategy. It is advised that small companies use integrated marketing tools, especially those that can be accessed with low budget, such as the Internet marketing tools (e.g. using social networking, micro-blogging, website, etc.), but also reach to the local consumers and build relationships with them by joining local and regional events.

b) Medium companies (101-500 employees) - the biggest part of the sample group was represented by medium sized food companies, and so there were fully efficient and inefficient companies found among this group. Those companies are generally focusing on national markets, usually having regional product lines as well. Their biggest challenge is facing the competition of big corporations who are usually more technically developed and have more resources for product and process innovations. In a way, the medium company's problems are the problems of both large companies (eg. managing implementation of new organizational innovations might be as difficult among 500 people as 1000 people) and small companies (eg. lack of financial resources for buying new patents, technologies, investing in in-house R&D, etc.). We could see in the results of inefficient companies, that the factors in need of improvements are spread throughout all dimensions. Therefore, the study suggests that medium food companies should focus on one kind of innovation dimension or factor and put direct their effort in that area first, instead of spreading it among all five dimensions, because it results in too high inputs level, whereas the output is not significantly increased. Also, it was found that different samples from the same company can have different innovativeness ability. For example, the sample B (Cookies) which is one of the inefficient samples, is produced by the same company that the sample I (Chinese style wine), which is the best example among all 100% efficient samples. Therefore, we suggest the companies identify which product categories within their organizations are the innovativeness leader and identify what are the reasons for it, and learn from their own managers or departments that are the most innovative.

In the results for medium inefficient companies, the biggest improvement suggestions were made for Communication and Cooperation (I8), Advertisement and Promotion (I11), New Managerial Methods (I10), Business Groups (I9) and Product Superiority (O1). Except of the Product Superiority, which is our output variable, all suggested potential improvement were negative in value, meaning the inefficient companies overemphasize those areas. It is worth to observe, that all those factors, except Product Superiority, are from Organizational and Marketing dimensions. It seems that due to the high competition that the medium sized companies face in the industry, they tend to overinvest in these areas.

c) Large companies (501 or more employees) - there were 7 samples representing this group in our study, representing convenience chain stores, supermarket chain stores, and instant noodles company. Three samples among this group got efficiency score lower than 100%. It was found that all the large companies generally has no problems with Process and Eco-

innovation dimension's factors, as well as the Green Supply Chain Management factor, of the eco-innovation dimension, as their input all got high scores in those areas. It is that the large size of the company goes usually together with material resources that play an important role in the product and process innovations. However, it can be observed that the inefficient representatives of the large companies tend to put too much effort/resources in the Product dimensions factors (especially Project-Company Fit, and Project Resources). As for the Eco-Innovation, it seems that there is a lot of social pressure, backed up with newly rising government policies, that the large corporations become more sustainable and 'go green'. Also, large companies need to be more careful in managing the safety of their supplies, as it can affect the safety of their final products, which in food industry is critical. The bigger the company, the easier it is to have a safety break in the supply chain. Implementing GSCM, as a part of Eco-innovation, is also often perceived by the consumer as safety facilitator.
Furthermore, a big challenge for large food companies is an efficient implementation of organizational innovations, which can bring cost-savings in large firms, because of the bigger scale of administrative and organizational processes and procedures. The results showed that Business Groups factors got too much efforts in case of both the medium and large companies. Even though joining a business group may be a goof leverage for the company, it might not always be the most efficient thing to do.

CONCLUSIONS

There has been no detailed research information about innovation and innovative ability of the food industry. Even though many researchers conducted studies in order to find innovative factors and key success factors for innovativeness in high-technology industry, they could not be directly translated into the food industry, which is a part of LMT industry. Therefore, collecting and organizing innovativeness dimensions and factors suitable for the food industry is the biggest contribution of this research.

On the other hand, the practical contributions of this study for the Taiwanese food industry would be: (1) Developing an assessment method for innovativeness of food industry companies that provides relevant, reliable and valid management information for the food industry in Taiwan, (2) Creating a benchmark for the food industry in Taiwan that can help to understand the innovative ability of the industry in Taiwan and also determine the space for improvements, (3) Proposing improvement strategies that can be used by companies that would find themselves below the benchmarked level, and (4) Developing special improvement strategies considering the size of the company, especially taking in consideration SMEs.

Even though the study focuses on the Taiwanese food industry, we believe that chosen innovativeness factors might be applicable in other researches, which are dealing with other LMT industries, or with countries other than Taiwan (e.g. researches about other Asian countries, or researches with global scope).

To sum up, the size of the company is important in designing and implementing the strategies for building and improving innovativeness of the firm to gain a competitive advantage in the marketplace. However, whatever the size of the company, it surely can be very innovative, as innovation is no more just a privilege of large enterprises. Also, it is worth

to observe the trends in eco-innovation dimensions in the future, as this dimension is relatively new and still growing in importance, and most probably its advantages will be fully seen in the future.

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E1 – Well-being

E1.1 **Factors of well-being at work in the work system model**
Tommi Autio

E1.2 **Distributed leadership for networked team performance**
Aelita Skaržauskienė

E1.3 **The antecedents and consequences of team reflexivity and innovative work behaviors of NPD teams: Multilevel of contingency variables**
Dr. Les Tien-Shang Lee

E1.4 **Constructing models for early chronic kidney disease detection and risk estimation**
Ruey Kei Chiu

FACTORS OF WELL-BEING AT WORK IN THE WORK SYSTEM MODEL

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ABSTRACT

This paper describes the study conducted by pilot study and following expert interviews to find out the factors of well-being at work and how those factors can be represented in the work system model. In addition this paper expands the original work system model adding the micro and macro level to the model to fully meet the requirements of the well-being at work.

Keywords: well-being at work, work system model, expert interviews,

INTRODUCTION

The population is aging in Europe and in other continents. This causes a variety of challenges in to working lives (e.g. Lutz et al., 2008; The demographic future of Europe – from challenge to opportunity, 2006). The ageing of the population is also one of the reasons why the well-being at work has been much discussed in recent years.

The Finnish institute of occupational health defines well-being at work as “safe, healthy, and productive work in a well-led organisation by competent workers and work communities who see their job as meaningful and rewarding, and see work as a factor that supports their life management” (Anttonen and Räsänen, 2008). Briefly and simply “well-being at work means employees’ capacity to manage and cope their work tasks.” It is influenced by several factors, such as the worker’s physical, mental and social condition as well as factors related to work society and work environment. Many other factors influence well-being at work too, for example remuneration, private and family life and life situation in general (Research on Well-Being at Work in Finland – Focusing in Occupational Health and Safety, 2005). Several studies have been shown that issues related to well-being at work interest employers, not least because these studies have indicated that well-being at work increases productivity (e.g. Ingelgård and Norrgren, 2001; Marjala and Haapasalo, 2008; Sparks et al., 2001). In addition the costs of absenteeism can be enormous (Danna and Griffin, 1999). Considering the well-being at work, understanding about the entirety could be more transparent, if the work itself is divided into smaller parts.

The work system model considers all the elements of work that affect the worker and outcomes systematically. The model includes five elements interacting with each other when performing certain part of work. These elements are: 1) a person who performs 2) his tasks using 3) tools (technology) needed 4) in his working environment and 5) work organisation. If a change occurs in some element of the work system, many changes may occur in other work system elements (Carayon, 2009). Balancing the elements of the work system in a way that satisfies the employee and enhances the quality and effectiveness is very complex (Carayon and Smith, 2000; Smith and Sanfort, 1989; Väyrynen, 2010).

OBJECTIVES

There are numerous definitions for well-being at work. Also a lot of research literature exists on well-being at work and its effects on productivity issues. There has been some discussion on how productivity can be improved by balancing work systems (e.g. Carayon and Smith, 2000; Kleiner and Hendrick, 2008). Nonetheless quite a little research exists regarding on how well-being at work could be improved by focusing and balancing work systems and thereby improving productivity. Often well-being at work is seen as a by-product outcome of a well-designed work system (e.g. Carayon, 2009).

In this study, the authors try to discuss how well-being at work can be the very part of the balanced work system model itself, and not merely an outcome. This is executed by allocating the empirical findings of the factors of the well-being at work into work system elements and by pondering their significance on the basis of literature. The above-mentioned can be condensed into three more specific research questions:

RQ1: What is the essence of well-being at work according to interviewed experts?
RQ2: Is it possible to represent the factors of well-being at work in the work system model?
RQ3: What parts of the work system model seem to affect the most to the well-being at work?

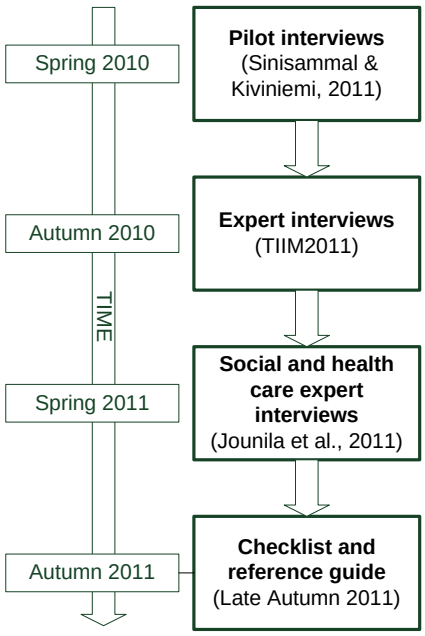

Figure 1: The timeline of the project from where the empirical material of this study was gathered.

This study is one part of a Finnish development project that aims to develop well-being at work in the municipality sector and it utilises empirical material which was gathered in that project (Figure 1). The project stakeholders include employees and management from two municipalities and private organisations and representatives from labour and employers' organisation. The project is still continuing and ends in the autumn of 2011.

METHODOLOGY

The main questions of the study were so extensive and focused at the same time that it was difficult to approach directly. Before committing to a full-scale research and expert interviews a small scale pilot study and pilot interviews were conducted as a test and rehearsal phase. As Teijlingen et al. (2000) for instance consider pilot study a crucial step in the research process. The goal of a pilot study is to identify, if not all, as many as possible flaws and weaknesses of the study protocol, equipment, methods etc. before actual research gets started.

Since the researchers already had preliminary, experience-based understanding of well-being at work, interviewing experts was regarded as an adequate method in order to achieve deeper and broader understanding about the issue (e.g. Hirsjärvi and Hurme, 2010).

The starting point of the pilot study and the pilot interviews was to design the questions to meet the definitions of well-being at work. After several discussions, fifteen questions were formulated. The questions covered topics e.g. occupational health and safety, communication, participation, the role of management and individual worker, and the effect of organisational values.

Twenty participants were selected based on their professional and representative experiences from different areas related to well-being at work. Informants included physicians, labour union representatives, occupational safety professionals, teachers and workers' safety representatives. Six experts participated in one focus group discussion (e.g. Langford & McDonagh 2003; Edmunds, 1999), other participants were interviewed individually. Five of the interviews were carried out by phone, one by videophone and the rest in a face-to-face setting. The interviews were documented by typing the answers in situ using a laptop computer.

After the pilot study, the next stage of the expert interviews was formed. This part of the study was composed of unstructured, open interviews for seven experts in the field of well-being at work at national level. The experts represent professionals at educational, consulting and university sectors. During the interviews, the experts utilised mind map - method for expressing their knowledge on the subject. The method is simple, easy to use and applicable to different kinds of situations. Mind maps are an efficient and quick way to accumulate data on the subject matter and its' factors and relations. The analysis yields a concrete and illustrative picture of the different factors. The method can be used alone, in pairs and small groups. As a method of group work it gives and amasses several different personal view points of the subject matter, adds to group cohesion and commitment as well encourages the processing of personal matters (Buzan, 2000; Farradi et al., 2002).

An open coding approach was utilised to summarise and synthesise the mind map data. First the researchers grouped the terms given by the experts under the five elements of the work system model. At the same time, the researchers removed the overlapping and totally the same terms from the lists. Secondly the terms that did not fit under these five elements were aggregated into their own group to wait for the conclusions of the research group. Because all these procedures this study is qualitative and interpretative in nature.

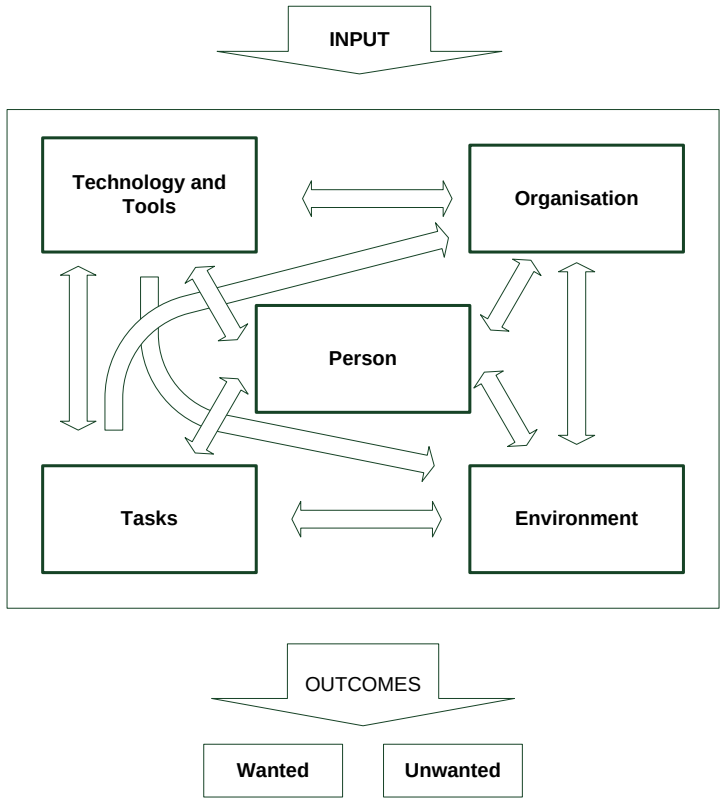

Figure 2: The balanced work system model aims to achieve the best relations of factors when pursuing wanted outcomes. (Väyrynen, 2010 modified and enhanced from Smith & Sainfort, 1989).

One of the research questions was that is it possible to represent the factors of well-being at work in the work system model. As mentioned earlier, the work system model provides a way to describe the elements of work that affect worker and outcomes of the model. The work system model includes five elements: the person (employee), tools and technologies, tasks, a physical environment and organisation (Figure 2). These five elements of the work system model interact with each other (Carayon, 2009). The balanced work system model aims to achieve the best relations of the factors by optimising the interaction of the employee, technology and tools, organisation, (work) environment and tasks. Productivity and well-being are the main positive outcomes when errors, accidents, sicknesses and discomfort are unwanted outcomes (Väyrynen, 2010).

RESULTS AND DISCUSSION

The pilot study and pilot interviews made it possible for the researchers to define and compose the content, the structure and used the methods of the next phase of the study. Followed expert interviews became more refined and more accurate to meet the requirements of the chosen research questions.

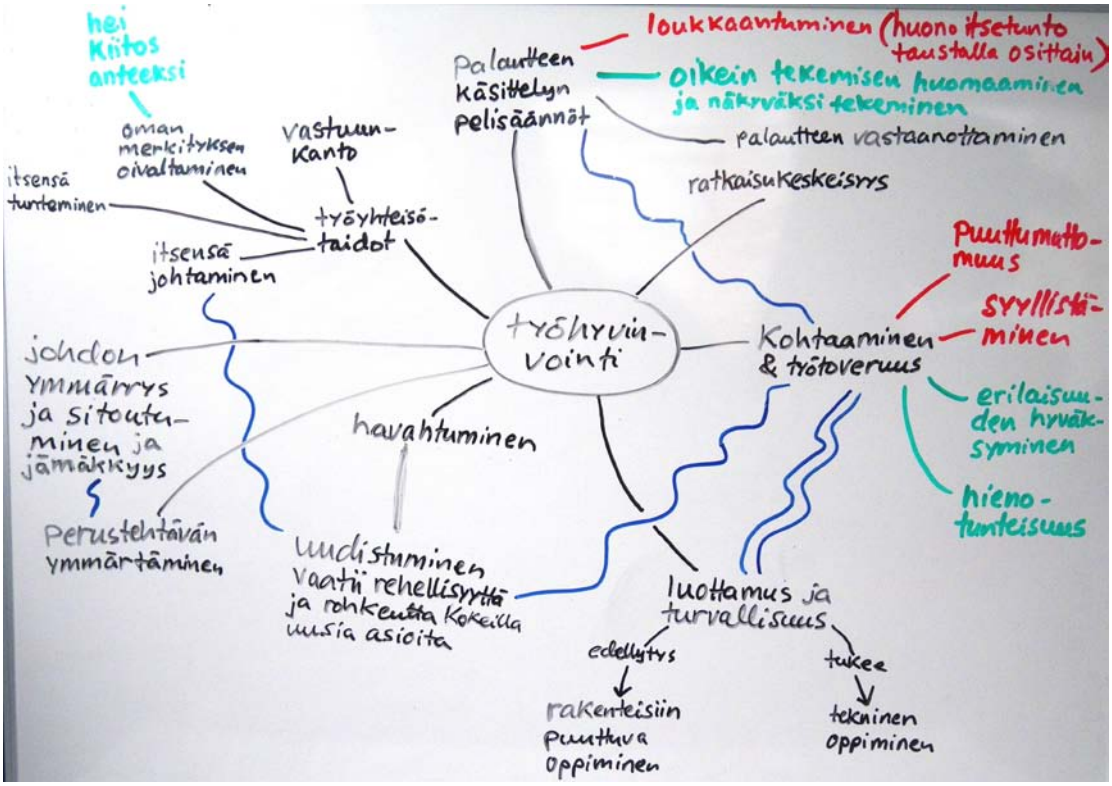

Figure 3: One raw mind map (out of seven) results from one expert interview.

After the expert interviews, researches had seven different (raw) mind maps formulated during the interview phase of the study. Mind maps represented the visions of the interviewees considering the main factors of well-being at work and all the cause and effect relationships between those factors as well (Figure 3).

Those raw mind maps were constructed and drawn again using somewhat similar terminology where applicable to find comparison between the mind maps. It was also necessary to see the cause and effect relationships between the factors affecting the well-being at work (Figure 4).

When researchers had gathered all the factors of the well-being at work collected from the expert interviews it was time to find out the common elements of those results. When expert interviews were carried out, researchers didn't instruct the interviewees to approach the question from the work system model point of view. All those different elements and terms used by the interviewed experts needed to be gathered together under the common topics, topics that eventually fit in the work system model.

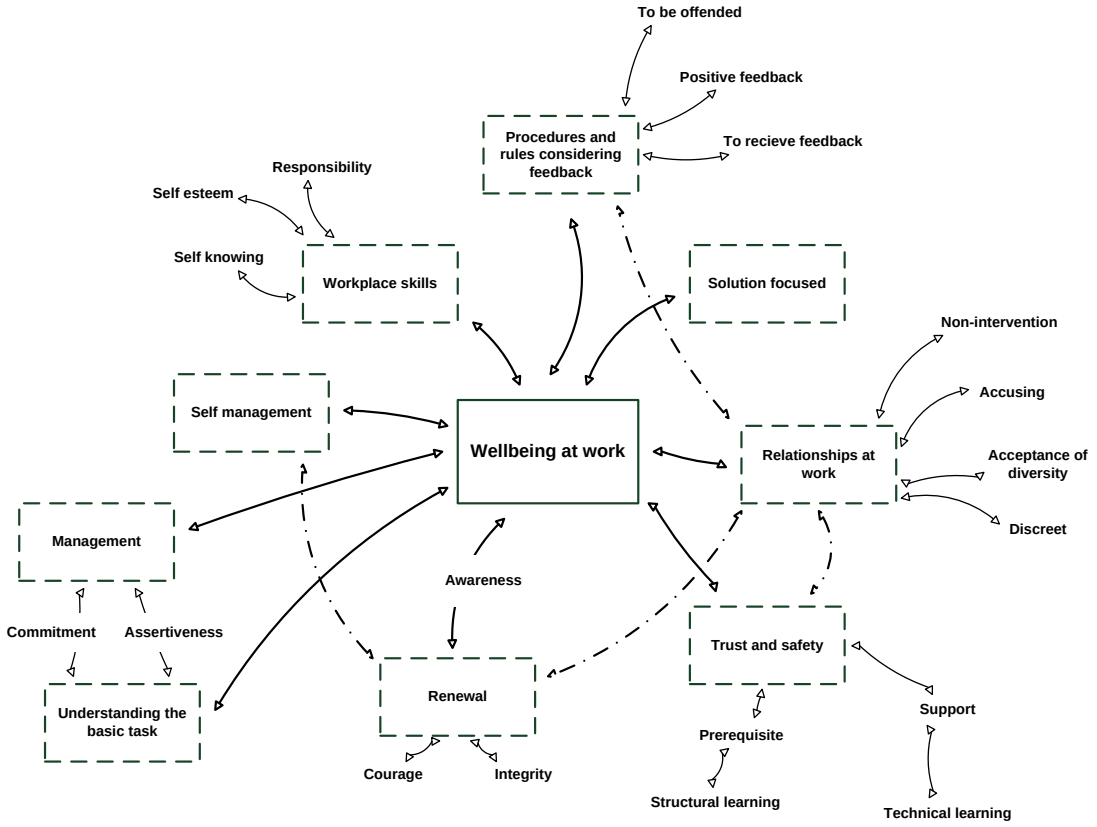

Figure 4: One out of seven mind map results from one expert interview.

The work system model represents the employee in the collaborative system with work environment, organisation and technology and tools used in to do the task itself (Figure 2). The work system model encompasses the psychosocial, cognitive and physical aspects of work that can create psychosocial, cognitive and/or physical loads on the individual. All those factors affect greatly into well-being at work. Therefore one of the main research questions of this study was to find out if the work system model can be used as the framework to describe well-being at work or does the model need more definitions or elements in it. In addition we pursued to find out what particular elements of the work system model are more definitive in comparison with others when considering the well-being at work.

Preliminary hypothesis was that the work system model can be effectively used to describe most of the factors of the well-being at work, but the model is not accurate enough to describe all the factors of the well-being at work.

One of the main goals of the study was to find the most influential parts of the work system model that affect directly or indirectly into well-being at work. We situated the factors of well-being at work gathered from the interviewed experts into the work system model. That symbiosis is shown in Figure 5.

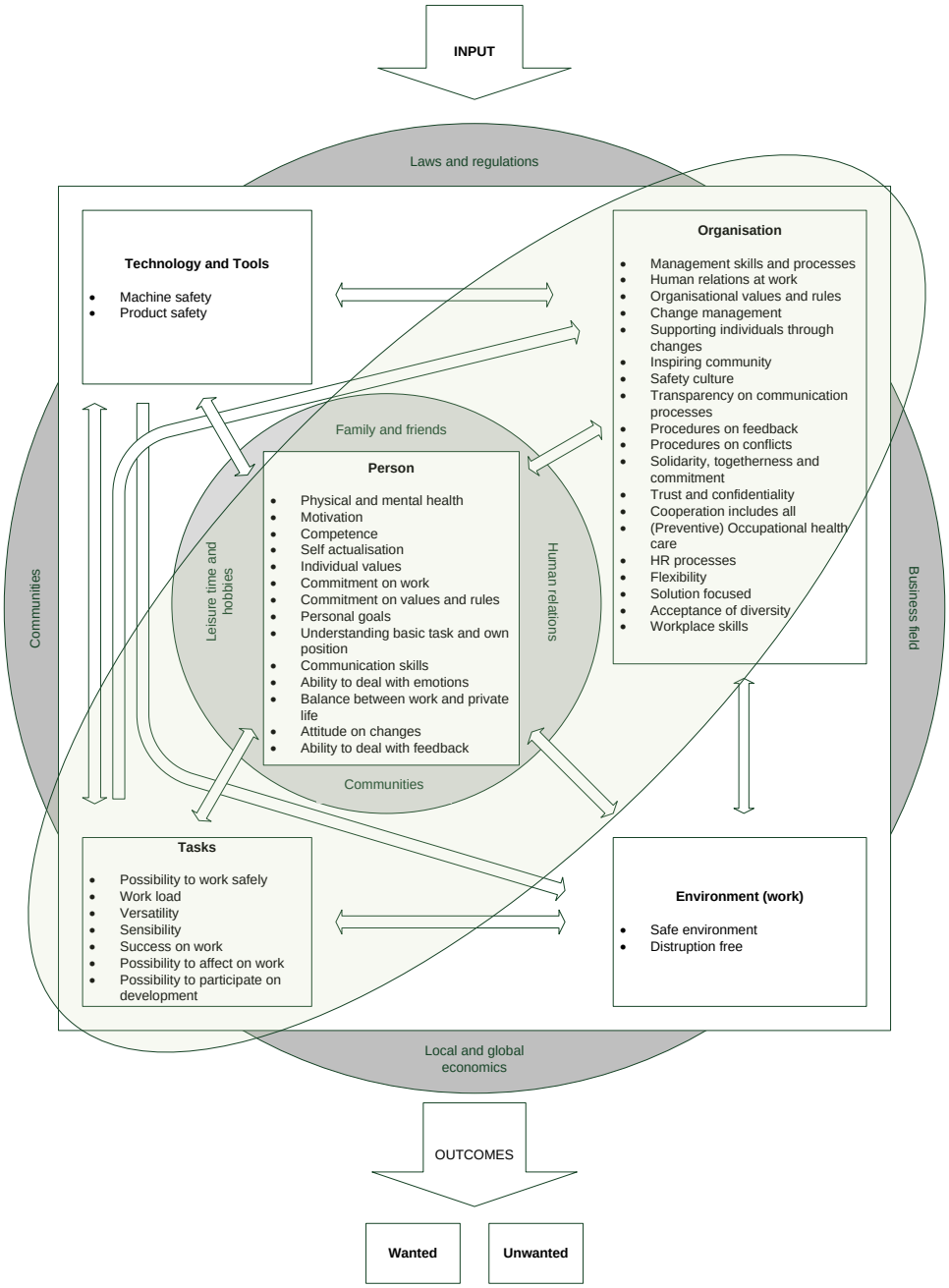

Figure 5: The factors of well-being at work in the balanced work system model after the expert interview phase of the study.

It was quickly discovered that subsections of the work system model that affected most to the well-being at work were “organisation” and “person” i.e. the worker itself. “Tasks” subsection got some effective factors that influence to the well-being at work, but “technology and tools” and “environment (work)” subsections were seen somewhat insignificant when discussing the effective variables toward well-being at work.

The organisation subsection is the major influencer considering the well-being at work. It includes the management itself and both management skills and management processes of the organisation have a major effect on the work related well-being altogether. It can be

seen that organisation subsection includes all those variables that create procedures, framework and even boundaries to the human relation interactions of all kind happening in the organisations. It has an effect on the management and procedures needed in communication between employer and the employee and it also greatly have an effect on the conducts between the employees.

The person subsection proved to be the second important influencer considering the well-being at work. It naturally includes all the physiological, psychological and cognitive variables of the person to affect all kind of well-being not just at work related. There was also motivation and competence based variables as well as commitment, self-actualisation and self-development to be found. The main notion on to the basic work system model was that there were more variables affecting the person than could fit in the original model. Therefore micro level had to be added to the model, micro level that affect to the person greatly, but is not part of the work system model.

The work related tasks the person (employee) is going to perform could also affect the well-being at work. The physical and mental loads are the major influencers but those form only the base level. The versatility and the sensibility of the work tasks can have huge input toward possibility to affect ones' work and eventually participating in development processes. All of which have positive influence toward well-being at work.

The conducted study indicates that the work system model itself is insufficient for representing all the factors considering the well-being at work. We had to consider both macro and micro levels that affect various factors in the system. Macro level includes all the "external" factors that affect into the work system itself such as laws and regulations, local and global economics and interaction in the business field, that are not included in the work system model as such even those variables take effect into well-being at work. On the other hand micro level represents the factors that affect into the employee itself considering the well-being at work. Those external factors include the social network such as family and friends and free time activities and hobbies that can greatly affect into well-being at work and thus productivity.

Other notable preliminary notion is that the interviewed experts emphasized the meaning of organisational practices and habits influencing the well-being at work together with personal factors expense of the meaning of technology, tools and work environment.

At the moment, the factors of the work system model include too many variables affect the well-being at work, too many to construct well-aimed and valid checklist or reference guide to follow when pursuing the better well-being at work. The study will continue when the next round of interviews is carried out. Those interviews are targeted to the experts working in social and health care business. That round of study aims to find the essence and the most influential factors in the work system model to affect the well-being at work based on the now existing work in progress model constructed and detailed in this study. After the next round of interviews and iterations a reference guide and/or check list considering the well-being at work can be build.

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DISTRIBUTED LEADERSHIP FOR NETWORKED TEAM PERFORMANCE

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ABCTRACT

Purpose *– This paper analyses the role of* ***distributed leadership in networked teams****. The team-based formal or informal networked or virtual (online) collaboration requires a different kind of leadership from that in positional hierarchies. Such leadership may be more flexible and sophisticated, capable of encompassing ambiguity and rapid change. Leaders in networked teams need to be partially invisible, delegating power and distributing task. Distributed leadership responses to complex situations and fosters team performance, facilitated through group interaction and decision-making, active distribution of specific tasks.*

Design/methodology/approach *– This paper makes an attempt to relate distributed leadership with the networked team performance. The paper follows a qualitative and quantitative research approach: case study and Insights Team Effectiveness Profile. Drawing on qualitative and quantitative evidence the paper analysis the complex process of the institutionalization of self-managing team approach through distributed leadership and networking in Department of Translators (A) in European Commisssion (EC) in Luxemburg.*

Findings *– Based on the analysis and synthesis of the scientific literature a conceptual model of relationship between distributed leadership and networked self-managing team was developed. The theoretical model was supported by empirical evidence from real public service organization in EC perspective. The analyses of research results revealed that distributed leadership was associated with higher networked team performance. Distributed leadership could be promoted as being well suited to public service organizations because of their multiple goals, less pronounced managerial authority and presence of powerful professional groups.*

Keywords: Networked team, Distributed leadership, Interactions, Collective Intelligence, Virtual team, Self-managing team, Team performance

INTRODUCTION

Today's organizational landscape is populated with work teams. Highly motivated and successful self-managing teams are the benchmark of successful organizations. The use and development of work teams, continues to be a prominent issue in different kinds of organization. This paper analyses the role of **distributed leadership in networked self-managing teams**. The team-based formal or informal networked (online) collaboration requires a different kind of leadership from that in positional hierarchies. Such leadership may be more flexible and sophisticated, capable of encompassing ambiguity and rapid

change. Recent developments in the field demonstrate that leadership and management is more complex, nuanced, and subtle than previously portrayed. Leaders in networked teams need to be partially invisible, delegating power and distributing task. Distributed leadership responses to complex situations and fosters team performance, facilitated through group interaction and decision-making, active distribution of specific tasks. In this context it is critical to understand the role of distributed leadership and particularly what are the key competencies to be developed in order to deal with the fluidity and complexity of the world.. This has led to look at leadership in a new light – and in particular to focus on how requirements of leaders have changed, what companies are doing to enable leaders to develop the required capabilities and what has been the impact.

The dominant organization priorities that were emerging as a result of the global economy are: *cost reduction*, *new technologies, networked and virtual organization etc.* These conditions require flexibility, collaboration, innovation and the courage to embrace uncertainty and ambiguity. Such extreme challenges require radical solutions and the transformation of leadership development. Innovation has been studied in a variety of contexts, in relation to technology, commerce, social systems, economic development, and policy construction. "We define innovation as the successful implementation of creative ideas within an organization. In this view, creativity by individuals and teams is a starting point for innovation; the first is necessary but not sufficient condition for the second" (Goyal. Akhilesh, 2007). In this paper we try to present distributed leadership in networked teams as an innovative management practice in public service organizations for addressing complexity, uncertainty and changes. Public organizations change the focus the ineffective bureaucratic models to more flexible communities of professional workers such as online communities, virtual self-managing teams, networked organizations etc.

Defining distributed leadership

J. Schumpeter (1950) believed that leaders are the people who make things to happen in the economy by transforming innovative ideas into practical opportunities. Much has been said of leadership throughout the last years. Different authors emphasize the importance of different factors, highlight different aspects, and use different terms for defining the role of the leader in the organization. The field of leadership – in theory and in practice – has been a fast-growing part of management knowledge since the beginning of the 20th century. In most conceptions of management and organization, leadership has a given and central place in enforcing principles, motivating employees and communicating future goals and visions. Leadership is assumed to make a special, significant and positive contribution to processes in most organizations, and leadership studies in academic field try to identify practices related to successful leadership. The field of leadership studies has traditionally been leader-centered, i.e. focused on the individual leaders and their traits, abilities and actions (Goyal, Akhilesh, 2007). Research on leader-follower exchanges shows that leader behavior which provides follower support (in terms of task-relevant direction or emotional relief) leads to enhanced follower motivation and commitment, transformational effects on followers are possible (Fletcher, 2004). Contemporary organizations emphasize the emergence of the relational, collectivist and non-authoritarian nature of leadership practices — opposing against unreflective mainstream perspectives that sustain heroic, individualist and authoritarian leadership norms (Crevani, Lindgren, Packendorff, 2010).

The concept of shared governance in the organization and management naturally aligns with distributed leadership defined by J.P. Spillane (2007) as „frequently used as a synonym for democratic leadership, shared leadership, collaborative leadership". The literatures contain several conceptualizations of such kind of leadership, such as *shared leadership*, *collaborative leadership* and *distributed leadership* (Bradford, Cohen, 1998). Current issues and future developments are discussed, with special emphasis given to the need for more research on distributed leadership. The idea of viewing leadership as spread throughout an organization is important but not new; it has been expressed for several years. In some situations, leadership is preferably a collaborative and collective responsibility where the responsibilities, competencies and decision-making need to be distributed onto several individuals rather than one (Collinson, 2007).

Distributed leadership as self-managing process

Conceptualizing leadership as a role that can be distributed among individuals within a team depending on the expertise required, is a critical theoretical transition given several important trends in modern organizations (Crevani, Lindgren, Packendorff, 2010). Specifically, organizations have seen an increased use of team, more problems that are rapidly emerging and complex, and an increase in the importance of innovation and adaptability. The benefit of utilizing distributed leadership with regard to these organizational developments is evidenced in a number of studies (Mumford, 2009). The findings of several compelling empirical studies point to a substantial benefit of distributed leadership to R&D project teams, and project teams in general. Two recent studies on research and development teams highlight the benefit of having multiple leaders. J. Hauschildt (2001) evaluated 133 new innovations within engineering industry and the effects that having multiple "champions", or leaders, taking on different elements of a leadership role, would have on the technical and financial success of the projects. As more leaders were involved in the development process, gains in performance increased by a factor of 30% to 50%.

Another important factor is that the distributed or collective leadership process is information-based. The distribution of information between members in the team or network and the exchange of that information is the foundation from which distributed leadership emerges (Mumford, 2009). Specifically, for the diverse skills and expertise of individuals to be effectively utilized, it is necessary for critical information regarding the problem to enter the network and be distributed among appropriate network channels. Effective information exchange is a driving force behind the self-managing among team members, information is the medium by which the leadership role is shared among a collective (Mumford, 2009).

Distributed leadership could be defined as "the distribution of leadership functions among the team, which is a group of people with formal leadership roles" (Hulpia, Devos, 2010). The definition of distributed leadership that will be used in this paper is that it is a dynamic leadership process in which a defined leader, or set of leaders, selectively utilize skills and expertise within a self-managing team, effectively distributing elements of the leadership role as the situation or problem at hand requires (Mumford, 2009).

In addition to defining the distributed leadership process, the goal in the present effort is to draw attention to the multi-level nature of this phenomenon, and to highlight the impact of distributed leadership on team performance.

The problem is that contemporary literature on leadership focuses on formulating new basic perspectives in leadership or new assumptions on how to do leadership research rather than on formulating new possible practical arrangements. It is not enough to say that leadership can successfully be shared between two or more co-leaders, or that it is about interaction between leaders and followers. „If we want to take leadership research beyond the leader-centered tradition, we must also challenge our deeply rooted tendency to make the abstract notion of „leadership" concrete in the work of individual managers" (Crevani, Lindgren, Packendorff, 2010).

Benefits of distributed leadership in teams

The social interaction of team members is an important factor contributing to successful distributed leadership (Spillane, Diamond, 2007). Most theories of organizational learning stress the importance of collective knowledge as a source of organizational capability. Organization and management researchers have extended the cognitive analysis to the team and organizational levels. Their analysis suggests that groups and organizations develop collective mental models (Senge, 1990) and interpretive schemes which affect group decision-making and action. Collective cognition differs from individual cognition because it encompasses a social dimension (Goyal, Akhilesh, 2007).

W.B. Arthur (1996) stated that in post-capitalist economies, wealth flows not to those who control financial capital, but to those who can acquire and direct intellectual capital. According to T.A. Stewart (1997) "Information and Knowledge are the thermonuclear competitive weapons of our time. Knowledge is more important than natural resources, big factories, fat bankrolls". At group or collective level cognitive ability called intelligence is a factor underlying creativity and innovation. In recent years, there has been a surge of research activity into **collective intelligence**. Massachusetts Institute of Technology, one of the most reputed academic institutions of USA has established a centre called the "MIT Center for Collective Intelligence" for understanding and taking advantage of the phenomenon of collective intelligence. Some of the notable outputs of collective intelligence, according to them, include Google, Wikipedia, and Innocentive (Goyal, Akhilesh, 2007).

Research indicated a positive relation between team members participation in **collective decision-making processes** and their organizational commitment. The effect of participative decision-making on organizational commitment varies in significance depending on a variety of conditions. These include the areas over which members have influence, administrative openness to such influence, normative acceptance of such opportunities, the organization of the participatory process, whether team members really have influence, and the results of the decision-making process (Hulpia, Devos, 2010). An open communication, which is defined by a work climate where people feel comfortable sharing ideas and information with other organizational members, strengthens organizational commitment. Similarly, E.

Mathieu (1990) claimed that good communication within the organization enhances the work environment and increases organizational commitment.

Over the last couple of decades, research on **emotions and affect in organizations** has become a popular area of study. The majority of research supports the idea that an individual's affect can have a significant influence on many aspects of their performance, such as creativity, decision making, and pro-social behaviors, among others (Barsade, Gibson, 2007) An interesting research question could be how affect might influence distributed leadership processes. Some progress has been made in evaluating the role of affective climate in organizations. Climate is a set of shared attitudes or expectations that a team has with regard to a specific context (e.g., climate for creativity, climate for safety) and thus, affective climate refers to a team's **creativity (**Pirola-Merlo, Härtel, Mann, Hirst, 2002). Affective climate has been included in the proposed framework of distributed leadership because research indicates that there is a relationship between affect and relational exchanges, feedback, contribution, conflict, and support networks (Mumford, 2009). This is a critical foundation for building long-term trust and engagement.

The final key distributed leadership component is **team performance parameters**. Some researchers have argued eloquently that distributed leadership can lead to improved effectiveness. R.F. Elmore (2000) claimed that since "instructional improvement requires that people with multiple sources of expertise work in concert around a common problem; this distributed expertise leads to distributed leadership". Distributed leadership in networked teams (NT) is quickly expanding research subject, but empirical findings based on a substantive sample of real NT remain limited at this time. NT (or virtual) are teams whose members do not share a common workspace all of the time, and must therefore interact and collaborate using networking, communication and collaboration tools such as email, videoconferencing, networks etc. In this vein, distributed leadership is similar to the way in which messages are transferred in the human neurological system. Networks are structured like neurons within the brain. These connections are not flat, but rather a 3D, layered system of linkages. Neurons serve specific roles, but there is also emergent meaning when impulses follow certain paths. Similarly, there is meaning in the way information flows through specific patterns of team members (Mumford, 2009).

Given this reasoning, the empirical case study of leadership focuses on leadership practices as constructed in interactions. This paper explores application of networking technologies for building the self-managing team praxis in public service organization.

Case study: Distributed leadership in networked self-managing teams

Details of Preparatory Work. In the month of June 2008 the French consultancy company DEMOS received background information concerning self-managing team project in Department of Translators (A) at European Commission (EC). In August, a first meeting was organized with the Head of Unit, the Training Unit of EC, DEMOS and an academic researchers group. We agreed on having a closer encounter with the team and the reality of its working conditions before actually determining the final programme. In that respect we had interviews with 4 staff members, in different functions. The information gathered in these meeting inspired the framework of the self-managing team project. We decided to

develop a double track programme: a combination of content/work-related issues, some learning points about the self-managing team as well as it's functioning and building of a networked team for developing distributed leadership approach (s-projects using Synnet technology).

Self-managing teams (,,empowered teams") are self-sufficient groups of people working together with specific goals. They have the corporate authority, experience, responsibility and skills to enact their own decisions for the organization, to maximize the use of everyone's talents. Self-management is "a leadership decision that invites initiative and not followership"(...). The major challenges organizations face in changing from a traditional environment to a high-involvement environment include developing the teams and fostering a culture of support. Teams go through several stages of increasing involvement on their way to self-management. This journey could be never-ending from a learning and renewal perspective. Comprehensive training is also critical to developing effective self-managing work teams. Not only must employees learn to work effectively in teams and develop skills in problem solving and decision making, they also must learn basic management skills so they can manage their own processes. Additionally, people must be cross-trained in every team member's job.

Comprehensive training is critical to developing effective self-managing work teams. The training for these teams must be more interactive than for other types of teams. Not only must employees learn to work effectively in teams and develop skills in problem solving and decision making, they also must learn basic management skills so they can manage their own processes. Additionally, people should be cross-trained in every team member's job. The major challenges organizations face in changing from a traditional environment to a self-managing and include developing the teams and fostering high-involvement environment. Teams go through several stages of increasing involvement on their way to self-management. This period could take between two and five years, and is never-ending from a learning and renewal perspective.

The commitments made by participants following the project was focused on self-managing and establishing new leadership style – distributed leadership:

- open up communication within the team, bringing out the contribution to improvement of each of its members,
- provide development for the whole team, including training in group problem solving, mapping of ideas, and ways to give and receive feedback,
- provide team members with insight required to facilitate an environment of honesty, trust and emotional safety,
- develop levels of personal insight,
- take the fear and resistance out of change,
- align values and direction across the organization through broad discussion of issues,
- monitor action plans to ensure completion to the satisfaction of the team.

Details of the Project

The content of the planned programme was fully covered, although the sequence of some activities had to be adjusted according to the flow of the programme and the needs of the

participants. The presentation and discussion on internal procedures took more time than expected, but every minute of it was well spent.

The building up of distributed leadership was implemented through s- projects (using Synnet technology). The technology Synnet is interactive virtual technology for building networked organizations based on the increasingly popular “wisdom of crowds“ idea. The new method helps to organize the collective decision making process. The system creates possibilities for participants to present their ideas anonymous in the virtual space. For others, it allows anonymous evaluation on a certain scale. The system generates the feedback about best offered ideas. This allows to form an objective overview of the ideas of a group, the virtual “brainstorming”. Teamwork organized in the virtual space is a lot more mobile and problems that arise are solved much faster. The s-projects outcome were two action plans: one for increasing the common sense of purpose, mission and the sense of belonging, and another - for integrating new team members in the team life.

Some participants were heavily opposed to attend this teambuilding programme, because they were not informed about the objectives of it. Some of them meant, the teambuilding must be an event, not online projects, but after the changed the mind after successful discussion about objectives of this teambuilding.

Evaluation of the Project

The objectives of the project were achieved. We used a flexible time table and methodology in order not to put pressure on the participants; the atmosphere during the whole event was respectful and constructive. There were moments of great concentration and involvement. Reviewing in a final round at the end of the programme, participants were very positive, pleased with the result, both the content and the atmosphere. Of course a critical comment should always be there: one participant expressed his doubt about the value of this kind of teambuilding programme. Many participants were enthusiastic. For some brand new team members, it was an extra-ordinary way of being introduced in their new team, getting acquainted with the content and the colleagues. The team members better realize that defining their identity as a team is not a given, but something to be achieved. The unit, not being a ‘real team’, can easily loose its sense of common purpose and belonging.

Project outcomes:

- A significantly enhanced understanding of how emotional baggage holds the individual team members and others back.
- An understanding of the power they have to impact upon the lives of others and the well-being of the team.
- Recognizing the link between personal empowerment and accountability.
- A clear understanding of the benefits to them of working as part of a forward moving and cohesive team.
- The skills for more effective communication within the team and beyond.
- Powerful skills for problem solving within the team.

Follow-Up

The next challenge for the unit is to start working in self managing teams. Every team will plan to distribute tasks itself among its members. Using s-projects approach the team will plan and guard the process on its own, solve daily problems, without always having to consult the manager or supporting services. Mutual perceptions and lack of understanding can easily affect a respectful relationship. Further building up the level of trust within the unit by giving personal feedback on the way the workflow should be organized .This feedback should be part of an ongoing process trying to improve continuously the collaboration in order to meet the mutual expectations at all levels and enhance performance. It was literally said in the review of the event that this activity should be organized on a regular base, like annually. This kind of follow up will definitely increase the impact, because it becomes a process of permanent improvement, rather than a one shot operation.

Evaluation of team performance. Empirical evidence

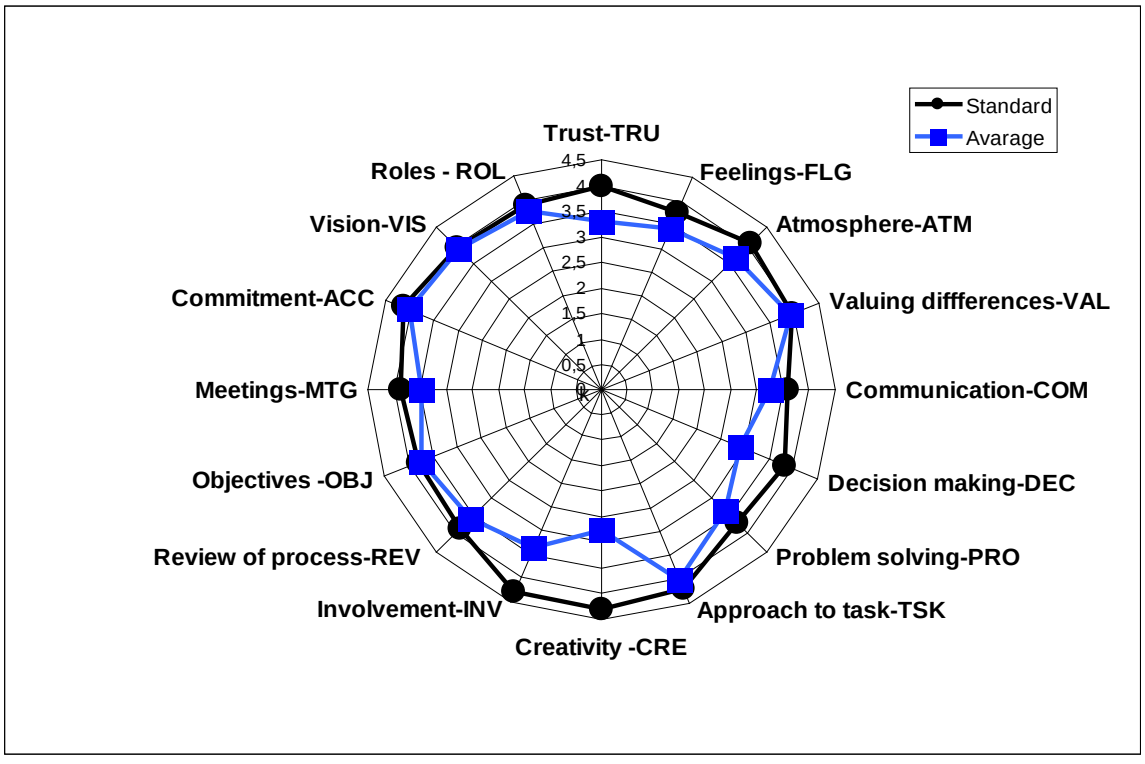
For evaluation of team performance Insigths Team Effectiveness Diagnostic was used to measure how team A is performing against critical success factors both at the beginning and over a period of time – at the end of the project (9 month period). “Insigths” is a global learning and development company working in partnership with leading organzations across the world (www.insights.com). This innovative evaluation acts as a great pre or post assessment as well as a snapshot diagnostic for teams that are struggling to be effective. The research results were used to support the establishment of performance improvement plans and benchmark team team culture performance against other teams. Each team member completed a 42-question evaluator on how they perceive the team's effectiveness in each of the 16 key areas. Team members (38 members) evaluated the team against 16 critical success factors. These sixteen elements are evenly spread around the Insights wheel. Team performance parameters are particularly critical in the distributed leadership process given that they are proposed to be behavioral indicators of a capacity for distributed leadership, antecedents to team processes, and a gateway to team performance capabilities and outcomes. The variables included within team performance parameters cover a wide range but fall into three general groups: capacity for problem-solving, team orientation, and team structuring and maintenance (Mumford, 2009).

The evaluation of team performance at the beginning of the project demonstrated significant differences (Figure 1) from the standard team performance and team A effectiviness. Size effect value should be interpreted as follows (Field, 2005): small size effect (r bellow 0.3), average size effect (between 0.3 and 0.5) and big size effect (more than 0.5). The team in department was highly centralized and bureaucratic, with a lot of formalization and standardization. The biggest negative differences exist in *Creativity* (-1,53), *Decision making* (-0,94), *Involvement* (-0,94), Trust (-0,66), as avarage could be described differences in *Feelings, Atmosphere, Communication, Problem solving, Meetings.* There are no statistically significant differences in *Valuing differences Approach to task, Review of process, Objectives.*

Figure 1: Critical success factors and its evaluation before the project.

Critical success factors	Standard	Avarage	Deviation before the project
Trust - TRU	**3,97**	**3,31**	**-0,66***
Feelings - FLG	**3,76**	**3,40**	**-0,36***
Atmosphere - ATM	**4,03**	**3,63**	**-0,40***
Valuing differences - VAL	3,96	3,92	-0,04
Communication - COM	**3,58**	**3,25**	**-0,33***
Decision making - DEC	**3,83**	**2,89**	**-0,94***
Problem solving - PRO	**3,67**	**3,35**	**-0,32***
Approach to task - TSK	4,22	4,00	-0,22
Creativity - CRE	**4,29**	**2,76**	**-1,53***
Involvement - INV	**4,29**	**3,35**	**-0,94***
Review of process - REV	3,83	3,54	-0,29
Objectives - OBJ	3,81	3,75	-0,06
Meetings - MTG	**3,87**	**3,48**	**-0,39***
Commitment - ACC	**4,16**	**3.60**	**-0,56***
Vision - VIS	3,94	3,89	-0,05
Roles - ROL	3,90	3,78	-0,12

Note: * Statistically significant difference



Observing interactions and practices one may choose to concentrate on what certain interactions 'do' as they are performed, but also to follow how interactions develop during a period of time. The evaluation of team A performance at the end of the project (in 9 month) demonstrated significant improvement of team work (Figure 2). The biggest negative differences exist again in *Creativity* (-0,75), *Involvement* (-0,73), *Trust* (-0,47), as avarage could be described differences in *Feelings, Meetings,* but all other 11 critical success factors demonstrated no statistically significant differences.

Figure 2: Critical success factors and its evaluation after the project

Critical success factors	Standard	Avarage	Deviation at the end of the project (in 9 month)
Trust - TRU	**3,97**	**3,5**	**-0,47***
Feelings - FLG	**3,76**	**3,4**	**-0,36***
Atmosphere - ATM	4,03	3,99	-0,04
Valuing diffferences - VAL	3,96	4,1	0,14
Communication - COM	3,58	3,55	-0,03
Decision making - DEC	3,83	3,78	-0,05
Problem solving - PRO	3,67	3,5	-0,17
Approach to task - TSK	4,22	4,21	-0,01
Creativity - CRE	**4,29**	**3,54**	**-0,75***
Involvement - INV	**4,29**	**3,56**	**-0,73***
Review of process - REV	3,83	3,89	0,06
Objectives - OBJ	3,81	3,83	0,02
Meetings - MTG	**3,87**	**3,52**	**-0,35***
Commitment - ACC	4,16	4,00	-0,16
Vision - VIS	3,94	3,9	-0,04
Roles - ROL	3,9	3,86	-0,04

Note: * Statistically significant difference

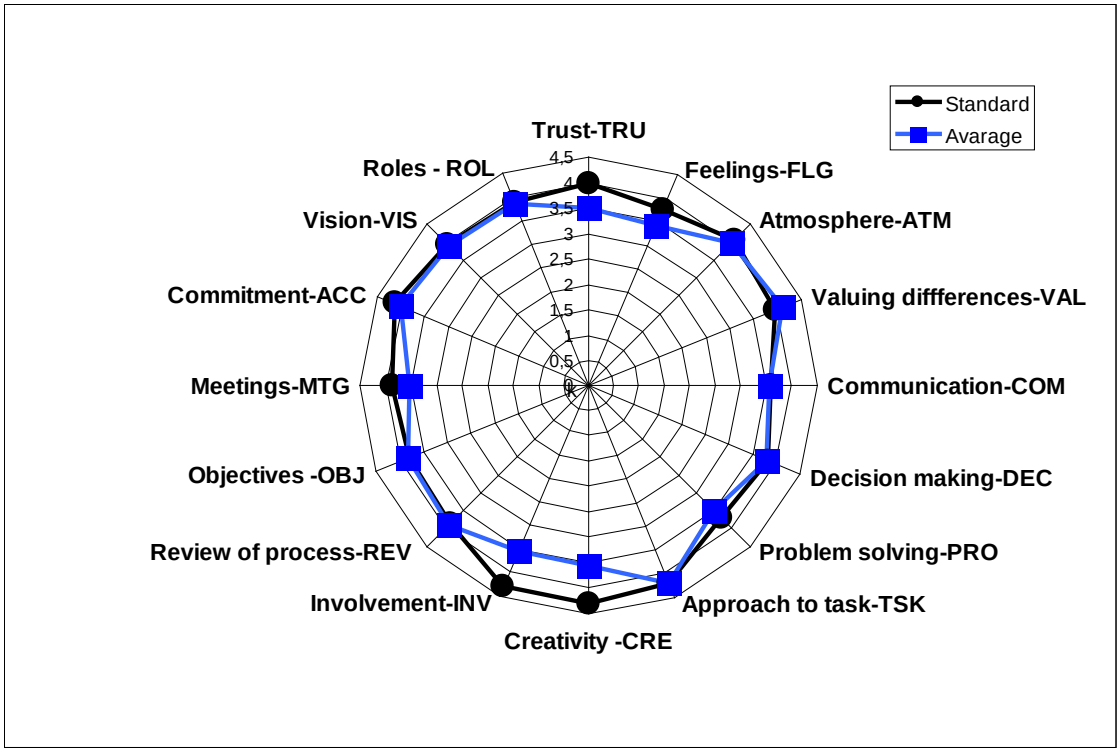


Figure 3: Critical success factors and its improvement over the project period.

Critical success factors	Standard	Avarage at the end of the project	Avarage before The project	Improvement over 9 month period
Trust - TRU	3,97	3,50	3,31	0,19
Feelings - FLG	3,76	3,40	3,40	0,00
Atmosphere - ATM	**4,03**	**3,99**	**3,63**	**0,36***
Valuing diffferences - VAL	3,96	4,10	3,92	0,18
Communication - COM	**3,58**	**3,55**	**3,25**	**0,30***
Decision making - DEC	**3,83**	**3,78**	**2,89**	**0,89***
Problem solving - PRO	3,67	3,50	3,35	0,15
Approach to task - TSK	4,22	4,21	4,00	0,21
Creativity - CRE	**4,29**	**3,54**	**2,76**	**0,78***
Involvement - INV	4,29	3,56	3,35	0,21
Review of process - REV	**3,83**	**3,89**	**3,54**	**0,35***
Objectives - OBJ	3,81	3,83	3,75	0,08
Meetings - MTG	3,87	3,52	3,48	0,04
Commitment - ACC	**4,16**	**4,00**	**3,60**	**0,40***
Vision - VIS	3,94	3,90	3,89	0,01
Roles - ROL	3,90	3,86	3,78	0,08

Note: * Statistically significant difference

The research results demonstrated significant team performance improvement in *Decision making* (0,89), *Creativity* (0,86) and average improvement in *Commitment* (0,40), *Atmosphere* (0,36), *Review of process* (0,35), *Communication* (0,30) (see Figure 3). The project activities influenced all critical success factors expect of *Feelings,* as we can see form the Insights wheel the team work is after project more balanced (Figure 2).

CONCLUSIONS

1. The team-based networked organizations requires a different kind of leadership from that in positional hierarchies. Such leadership may be more flexible and sophisticated, capable of encompassing ambiguity and rapid change. In self-managing teams leadership is preferably a collaborative and collective responsibility where the responsibilities, competencies and decision-making need to be distributed onto several individuals rather than one.

2. In this paper a perspective within leadership research is suggested that has an analytical focus on distributed leadership as it is practiced in daily interaction, rather than on individual leaders. In the face of unrelenting commercial pressure, it has become essential to maintain a strong focus on people and relationships across the organization. It is only through collaboration that solutions are found and that the commitment can be built to successfully execute. The suggested perspective opens new understandings of how leadership activities emerge in social interaction.

3. In sum, distributed leadership has significant and beneficial implications for team performance and organizational processes. It creates a more efficient use of expertise and also increases the effectiveness of teamwork by distributing elements of the leadership role to those that are best suited to take them on. The research results demonstrated significant team performance improvement in decision making, commitment and communication, creativity and atmosphere in the team. The networking activities influenced all critical success factors of team effectiveness, facilitated through group interaction and decision-making, active distribution of specific tasks.

4. The implementation of distributed leadership in public service organizations is difficult and long process, that is, the very context where policy-makers expect distributed leadership to make the most impact. Moving beyond our specific case, we argue that distributed leadership, and leadership more generally, cannot be divorced from its institutional context and that the relative influence of divergent institutional forces depends upon the immediate organizational environment. However, teams and organizations can create conditions to foster and facilitate the process, encourage leaders and team members to approach leadership as a distributed effort. A team or organization could develop their distributed leadership capabilities using new technologies: building online communities, adapting virtual communication tools and creating networked projects.

5. Distributed leadership through efficient responses in which expertise is effectively and fast utilized, would be highly valuable. Flexibility that networked teams provide could help integrate a culturally diverse and multi-generational workforce. This, together with increased competitive and financial pressure, means that the trend toward networked teaming and distributed leadership could prepare organization for the extreme challenges. Organizations need to recognize the unique implications of Climate, Process, Focus and Flow in the virtual environment and invest the time and effort to generate real results. Effective networking could be organization's unique competitive advantage.

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THE ANTECEDENTS AND CONSEQUENCES OF TEAM REFLEXIVITY AND INNOVATIVE WORK BEHAVIORS OF NPD TEAMS: MULTILEVEL OF CONTINGENCY VARIABLES

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ABSTRACT

This study regards team's ability for being reflexive is crucial to transform the members' knowledge and skills as well as teams' project orientation into innovative products. This study also considers innovative work behaviors as the crucial factor that determines NPD success.

This study also proposes that members' innovative behaviors are determined project management skills, existing knowledge, and project orientation that NPD teams had.

Moreover, this study proposes that there are four moderators involved in this study. First, the relationships between project management skills, existing knowledge, and project orientation on innovative work behaviors have different magnitudes in different conditions. Second, the effects of antecedents of team reflexivity will be moderated by task familiarity. Third, the positive effects of team reflexivity and innovative work behaviors on new product success are strengthened when the NPD teams perceived that their management treated them fairly. Fourth, the task conflict also serves as the moderator between innovative work behaviors and team reflexivity on the NPD outcomes.

This study developed 18 propositions with a comprehensive research model for NPD success. Since the development of this model is still on the exploratory stage, it is suggested that further empirical validations are required to identify the robustness of this proposed research. It is expected that the results of this study can serve as a benchmark for academicians to further investigate this research issue. The study results will also be very useful for practitioners to design appropriate mechanism for the management of NPD team.

Keywords: project management skills, innovative work behaviors, team reflexivity, regulatory focus, task familiarity.

INTRODUCTION

Research Background

New product success has been an important issue in new product development (NPD) research. Previous study indicate that the average success rate of NPD in USA was 59%, whereas 100 ideas lead to 15.2 successful new products. Recent study reports that the success rate in Hong Kong is 44.91%, and 100 ideas only lead to 2.15 successful new products. These facts attract more attentions from academicians and practitioners to investigate how to increase the success rate of NPD. One of the key determinants of new product success is product innovation. This study defines innovation as uniqueness (Cooper & Kleinschmidt, 1987) or newness (Jordan & Segelod, 2006) of the product. Therefore, developing new product which offers uniqueness or newness is the ultimate way for company to make their product success in the marketplace.

Currently, organizations are increasingly relying on teams to innovate and respond to the rapidly changing marketplace (e.g., West, 2002). In other words, an organization needs to maintain and strengthen their NPD teams if they are going to innovate. This study regards team's ability for being reflexive (West, 1996, 2002) is crucial to transform the members' knowledge and skills into innovative products. This study asserts that team reflexivity determined by members' project management skills (Hoegl and Parboteeah, 2006). The skills are necessary for flexible planning and ongoing controlling of the task process, which is of particular importance in the case of innovative projects, since it has high degree of task-related uncertainty and complexity. Moreover, NPD teams will have capability to be reflexive when they have adequate knowledge on certain issues related with the newly developed product. Refer to Brockman and Morgan (2006), members' knowledge is critical to determine the quality of reflexivity that team's has. When the members' have adequate level of knowledge and project skills, team's reflection could generate innovative ideas. Furthermore, this study proposes that project orientation also determine the level of team reflexivity, either customer- or competitor-related orientation (e.g., Kohli and Jaworski, 1990; Homburg et al., 2007).

In addition, this study considers innovative work behaviors as determinants of NPD success. This study argues that NPD team members' intentional introduction or application of new ideas, products, processes, and procedures to their team (West and Farr, 1989, 1990b; Yuan and Woodman, 2010) also will facilitate the success of NPD. Despite proposing ideas from themselves, innovative work behaviors also includes the ability to adopt others' ideas that are new to one's organization or work unit (Woodman et al., 1993). Similar to the antecedents of team reflexivity, this study proposes that members' innovative behaviors are determined project management skills, existing knowledge, and project orientation that NPD teams had.

Finally, this study proposes that there are four moderators involved in this study. First, this study asserts that the relationships between project management skills, existing knowledge, and project orientation on innovative work behaviors have different magnitudes in different conditions. This study argues that regulatory focus (Higgins, 1997) could serve as the moderator. Specifically, this study argues that the relationships will be strengthened when the

NPD team members are promotion-oriented than prevention oriented due to the concern for more accomplishments and aspirations, and thus they will be more creative in problem-solving processes (e.g., Brockner and Higgins, 2001; Friedman and Forster, 2001). Second, this study proposes that the effects of antecedents of team reflexivity will be moderated by task familiarity. This study argues that the positive effects of project management skills, existing knowledge, and project orientation on team reflexivity will be strengthened when the NPD team members are familiar toward their current tasks. Third, this study proposes that the positive effects of team reflexivity and innovative work behaviors on new product success are strengthened when the NPD teams perceived that their management treated them fairly. The greater perceived procedural justice, the more likely they are to trust the organization; this will interact with outcome favorability - work behaviors, such as developing innovative products. Fourth, this study proposes that task conflict also serves as the moderator between innovative work behaviors and team reflexivity on the NPD outcomes. Task conflict fosters learning and the development of new and sometimes highly creative insights, leading the group to become more effective and innovative (Jehn, 1995). By experiencing task conflict, NPD team members will have greater team reflexivity and innovative work behaviors by the deep and deliberate processing of task-relevant information, during which the development of new and creative insights will be fostered leading the team to become more effective. On the other hand, relationship conflict has only a detrimental role on team performance.

LITERATURE REVIEW

Theoretical Background

Project Management Skills

Project management skills refer to team members' abilities to plan and control projects. This includes abilities to structure the team task and to plan the workflow (Gladstein, 1984). To be effective, teams must organize themselves in a way that allows all team members to work simultaneously without gaps and overlaps. Project management skills are necessary for flexible planning and ongoing controlling of the task process, which is of particular importance in the case of innovative projects, given their high degree of task-related uncertainty and complexity. This study follow the Hoegl and Parboteeah's (2006) argument that a team's project management skills are positively related to team reflexivity, as a high level of task structuring and coordination offers the basis for, and likely prompts the awareness of, its current work status relative to given quality, budget, and schedule expectations. As such, teams that have the skills to properly structure and control their task processes will likely demonstrate higher levels of team reflexivity, scanning internal and external environments for feedback based on proper information regarding current task status, routinely re-evaluate chosen task strategies and are prepared to alter them if the situation calls for such action.

Existing Knowledge

Existing knowledge similar with organizational memory proposed by Moorman and Miner (1997) which defined as collective basis, behavioral routines, or psychological artifacts that vary in their content, level, dispersion, and accessibility (Brockman and Morgan, 2006). It has been recognized as an essential component of organizational learning (Slater and Narver 1995); the depth and breadth of an existing knowledge base determines how easily new information is incorporated. Because NPD is considered an organizational learning process (Leonard-Barton 1992), research on the role of existing knowledge in NPD is relevant. According to Moorman and Miner (1997), the link between existing knowledge and new product innovativeness and found an insignificant relationship between the two variables. However, this study assumed that organizational memory which refers to collective basis or behavioral routines in the organizations play determinant role of product innovativeness. Moreover, it assumed that these behaviors will determine the level of team reflexivity in the new product development project.

Project Orientation

According to Homburg, Grozdanovic, and Klarmann (2007), responsiveness is typically a main facet of market orientation. They further proposed that there are two different kinds of responsiveness: "customer-related responsiveness as the extent to which an organization responds quickly to customer-related changes, and… competitor-related responsiveness as the extent to which an organization responds quickly to competitor-related changes" (Homburg et al., 2007, p. 19). Based on that, this study will adopt this perspective and operationalizes project orientation as customer-related and competitor-related responsiveness. This study asserts that timely responses to customer-related changes and competitor-related changes have several beneficial consequences for NPD teams.

Team Reflexivity

Group members face obstacles as they try to coordinate effort, strengthen interpersonal relationships, and integrate ideas. Groups need considerable management to identify frustrations and develop and implement solutions. West (1996, 2000, 2002) has labeled this group management as team reflexivity and defined it as the extent to which team members collectively reflect on and adapt their team's objectives, strategies, and processes. Teams monitor and become aware of how they work together and develop and implement improvement plans. Reflexivity would also seem to require a degree of entitativity, which is the extent to which group members believe themselves to be one unit (Lickel, Hamilton, and Sherman, 2001). Reflexivity is expected to help teams know their actual workings and develop new understandings and methods that respond to emerging conditions and challenges (Carter and West, 1998). Reflexivity is especially useful for groups working on challenging tasks and operating in complex environments. The major implication is that to the extent that teams engage in reflexivity are able to continue to perform effectively (Frese and Zapf, 1994; Johnson, Johnson, Stanne, and Garibaldi, 1990), and can keep groups focused and efficient.

According to West (1996, 2000, 2002), there are three central elements to the concept of reflexivity—reflection, planning, and action or adaptation. Reflection consists of attention, awareness, monitoring, and evaluation of the object of reflection. Planning is one of the potential consequences of the indeterminacy of reflection, since during this indeterminacy, courses of action can be contemplated, intentions formed, plans developed (in more or less detail), and the potential for carrying them out is built up. High reflexivity exists when team planning is characterized by greater detail, inclusiveness of potential problems, hierarchical ordering of plans, and long as well as short range planning. The more detailed the implementation plans, the greater the likelihood that they will manifest in innovation (Frese and Zapf, 1994; Gollwitzer, 1996). Indeed the work of Gollwitzer and colleagues suggests that innovation will be implemented almost only when the team has articulated implementation intentions. This is because planning creates a conceptual readiness for, and guides team members' attention towards, relevant opportunities for action and means to implement the innovation. Action refers to goal-directed behaviors relevant to achieving the desired changes in team objective, strategies, processes, organizations, or environments identified by the team. In a variety of studies links between reflexivity and team innovation and effectiveness have been demonstrated (Carter and West, 1998; West, Patterson, and Dawson, 1999; Borrill et al., 2000). This study uses these dimensions - reflection, planning, and action or adaptation – to represents the team reflexivity which will influence the product innovativeness of NPD teams resulted as well as the new product performance.

Innovative Work Behaviors

Drawing on West and Farr (1989, 1990b), Yuan and Woodman (2010) define innovative behavior as an employee's intentional introduction or application of new ideas, products, processes, and procedures to his or her work role, work unit, or organization. Examples of such behavior include searching out new technologies, suggesting new ways to achieve objectives, applying new work methods, and investigating and securing resources to implement new ideas. In keeping with Kanter (1988), Janssen (2000), and Scott and Bruce (1994), this study asserts that innovative behavior as complex behavior consisting of activities pertaining to both the generation/introduction of new ideas (either by oneself or adopted from others) and the realization or implementation of new ideas. One related construct in the literature is creative behavior, which refers to behavior pertaining to the generation of ideas that are both novel and useful (Amabile, 1988; Oldham and Cummings, 1996). Creative behavior can be considered as one type of innovative behavior because innovative behavior includes not only generating novel ideas by oneself but also adopting others' ideas that are new to one's organization or work unit (Woodman et al., 1993). Also, creative behavior concerns new idea generation, whereas innovative behavior includes both the generation and implementation of new ideas (Shalley et al. 2004; Zhou, 2003).

This study asserts that members of NPD teams have innovative work behaviors as the rational decisions of innovative acts to support the functioning of the team.

Outcomes

At the firm level, this study operationalizes based on financial and market performance. Previous studies mostly employ financial performance as the consequence of the adoption of NPD (e.g., Jordan and Segelod, 2006; Weerawardena and O'Cass, 2004). Another consequence is performance related to market measurements. NPD programs can create better customer satisfaction and enhance their business image, and thus it might improve business reputation. Good reputations provide the rationale for a cross-sectional relationship between reputation and financial performance. Specifically, good reputation may enable the organization to charge premium prices, attract better applicants, enhance their access to capital markets, and attract investors. Based on that, this study operationalizes organizational performance based on managers' perceptions of their firms' financial and market performance.

Regulatory Focus

Higgins (1997, 1998) developed the regulatory focus theory, which describes important differences in the processes through which people approach pleasure and avoid pain. Self-regulation refers to the process by which people seek to align themselves (i.e., their behaviors and self-conceptions) with appropriate goals or standards (Brockner and Higgins, 2001). Specifically, Higgins (1997) proposed that people have two basic self-regulation systems. One regulates the achievement of rewards and focuses individuals on promotion goals, while the other regulates the avoidance of punishments and focuses individuals on prevention goals. Promotion goals represent the "ideal self" and include hopes, wishes, and aspirations, whereas prevention goals represent the "ought self" and include duties, obligations, and responsibilities.

Regulatory focus theory can be thought of as one of the most comprehensive motivation theories, since its constructs seem to comprise a primary element of human motivation. Previously, motivation has been examined by focusing on individual differences in approach-related versus avoidance-related emotions (e.g., Gray, 1982; Sutton and Davidson, 1997). In contrast to the approach-avoidance literature (e.g., Gray, 1982), regulatory focus theory suggests that there are different pathways to achieve different desired end states (Higgins, 1997). Since export behavior focuses on bringing about desired end states, this theory is particularly appropriate for analyzing the different possible outcomes of export behaviors. This study expects that managers' or owners' regulatory focus, through the manipulation of work context, can affect the situational factors of the regulatory focus, priming followers' promotion or prevention focus and shaping their motivations.

Task Familiarity

The concept of familiarity in organizational teams has been defined as "the knowledge that members of a team have about the unique aspects of their work" (Goodman and Garber 1988), such as knowledge about the task itself and about other members on the team (Littlepage et al. 1997). As members of a team work together over time, they become familiar with the task domain and with each other, and they develop a common knowledge base through which team

interaction and location of expert sources in the team can occur (Alavi and Leidner 2001). This study focuses on task familiarity rather than team familiarity, since it deals with the innovation outcomes, whether it is radical or incremental innovation.

Procedural Fairness

Based on organizational justice theory (Greenberg, 1987), procedural justice refers to the perceived fairness of the processes used to determine the outcomes received (Colquitt et al., 2001). The basic premise is that fair treatment determines individuals' reactions to decisions and is thus central to their behavior (Lind and Tyler, 1988). It emphasizes structural elements such as process control as major determinants of fairness perceptions (Greenberg, 1987). Procedural justice researchers argue that organizational members are concerned about the fairness of the procedures that govern or affect organizational members, because procedural fairness signals a member's positive or valued position within the organization or group (Lind and Tyler, 1988, Tyler and Lind, 1992).

In the context of NPD teams, Li et al. (2007) define perceived procedural justice as "a project member's perceptions of the fairness of rules and processes used by top management to make decisions regarding the development of new products" (p. 201). Fair in the context of NPD such that procedures and criteria used to screen, create, appraise, and test new product are unbiased, representative, transparent, correctable, and ethical (Luo, 2008). In summary, this study asserts that procedural justice is NPD teams' perception toward how fair the rules and processes being set up by the management regarding the development of new product.

Team Conflict

Team conflict refers to a process resulting from the tension between team members because of real or perceived differences (e.g., De Dreu, Harinck, and Van Vianen, 1999; De Dreu and Weingart, 2003). Because team members contribute to the team through social inputs and task inputs (e.g., Forsyth, 1983), conflict in teams is concerned with relationship and task issues (e.g., Amason and Schweiger, 1997; Jehn, 1997). Examples of relationship conflict are conflicts about personal taste, political preferences, values, or interpersonal style. Examples of task conflict are conflicts about the distribution of resources, about procedures and policies, and about judgments and interpretation of facts. Task conflict increases group members' tendency to scrutinize task issues and to engage in deep and deliberate processing of task-relevant information (Amason, 1996; Amason and Schweiger, 1997; Jehn, 1995, 1997), while relationship conflict tends to result in a focus of members on each other rather than on the assigned task (De Dreu and Weingart, 2003). This fosters learning and the development of new and sometimes highly creative insights leading the group to become more effective.

Research Propositions

The Determinants of Innovative Work Behaviors

This study argues that being innovative in the workplace, such as in the context of NPD teams, need to have basic requirements. Project management skills refer to team members' abilities to plan and control projects, and its necessary for flexible planning and ongoing controlling of the task process, which is of particular importance in the case of innovative projects, given their high degree of task-related uncertainty and complexity. With these skills, it can be expected that NPD team members are expected to be innovative by introducing several planning and how to implement those planning. Furthermore, Narver and Slater (1990) proposed that existing knowledge is an essential component of organizational learning (Slater and Narver 1995); the depth and breadth of an existing knowledge base determines how easily new information is incorporated. In other words, when the NPD team members have sufficient existing knowledge related with current assignments, it can be expected that they will have greater innovative work behaviors.

In addition, this study argues that project orientation positively contributes to innovative work behaviors. As described previously, NPD teams might have customer- or competitor-related responsiveness (Homburg et al., 2007). Either one, responsiveness of the NPD team members toward customer- or competitor-related changes will increase the innovative work behaviors from the members. Following the social-political perspective in understanding innovation (Yuan and Woodman, 2010), this study also argues that being innovative is a prerequisite to impress others. Individuals' reality is, at least partially, socially constructed. Individual behaviors have both technical and symbolic functions. Regardless of whether the introduction of new ideas or procedures will help to improve efficiency or performance, the act of engaging in innovative behaviors is a signal; it conveys information about an actor to the social context. Other people's potential perceptions or impressions are important determinants of individual behavior because such impressions influence others' reactions to the actor and therefore the possibility for the actor to get necessary resources and social support to achieve goals. In a product design firm, Sutton and Hargadon (1996) found that design engineers used brainstorming sessions as "prestige" or "status auctions"—that is, as opportunities to impress their peers and establish favorable social images. Thus, when NPD teams have customer- or competitor-related responsiveness, the members will tend to introduce innovative ideas in order to impress each other. Therefore, the following two propositions are developed.

Proposition P_1: Innovative work behaviors are positively influenced by (a) project management skills and (b) existing knowledge of NPD team members.

Proposition P_2: Project orientation is positively influence the level of NPD team members' innovative work behaviors.

The Determinants of Team Reflexivity

This study asserts that having reflection needs some knowledge from team members, such as technical knowledge or behavioral routines (Brockman & Morgan, 2006), as materials to be processed further in the reflection process. Moreover, this study asserts that a team's project management skills are positively related to team reflexivity (Hoegl and Parboteeah, 2006). A team that has the skills to properly structure and control their task processes will likely demonstrate higher levels of team reflexivity, routinely re-evaluate chosen task strategies and are prepared to alter them if the situation calls for such action. Because reflexivity involves each team member to present their accounts of the situation, they are less likely to be judgmental about ideas of NPD and more likely to find the best solution to problems. The information sharing within the team and across the team is likely happen when all team members are better informed about problems they are facing and ways to solve them in NPD (Hoegl & Parboteaah, 2006). According to, the constant self-reflection fosters the ongoing collection and sharing of information that is so critical to project success.

As an aspect of corporate culture, project orientation places the highest priority on creating and maintaining superior customer value profitably, and provides firm-wide norms and beliefs that guide organizational behaviors (Narver and Slater, 1990). It consists of two behavioral components: customer orientation and competitor orientation. Customer orientation echoes the classic tenet of "stay close to the customer" and "put the customer at the top of the organizational chart" and therefore is the most essential part of a market orientation. Consequently, the NPD team needs to be more reflexive on any changes related with their customers. On the other hand, competitor orientation focuses on the strengths and weaknesses of its competitors. To response on any actions being taken by its competitors, NPD team also need to be reflexive in order to overcome the thgreats posed by the competitors. In summary, Day and Wensley (1988) propose that customer and competitor orientations are two distinct approaches that lead to competitive advantage. A customer orientation, with its detailed analyses of customer needs and wants, helps a firm satisfy its customers better, and thus is more likely to lead to a differentiation advantage. In contrast, a competitor orientation may lead to a cost advantage because competitor-oriented businesses tend to watch costs closely, so they may quickly match the marketing initiatives of competitors. These advantages could be reach when the NPD teams are being reflexive toward their current tasks. Therefore, based on the above literatures, this study proposed the following two propositions:

Proposition P_3: Team reflexivity is positively influenced by (a) project management skills and (b) existing knowledge of NPD team members.

Proposition P_4: Project orientation is positively influence the level of NPD team's reflexivity.

The Effect of Team Reflexivity

Team reflexivity allows NPD teams to continuously assess current situations and accurately understand objectives, making the teams effective and focused under dynamic market and

technological changes (Hoegl and Parboteeah, 2006). As a result, NPD teams have better problem solving abilities by solving the "right" problems in the right order, ultimately developing innovative products. Thus, it can be expected that NPD team members able to introduce and implement innovative work behaviors when their team is more reflexive. Furthermore, team reflexivity positively relates to higher levels of innovation and greater product performance (e.g., Carter and West, 1998; Tjosvold et al., 2004). Reflexive teams are also likely to make better use of team members' expertise, thus achieving better project success due to greater awareness of their fellow team members' expertise and skills. This comprehensive knowledge of team strength and weakness is likely to lead to better innovation as expertise is distributed in the most appropriate way. Moreover, each team member needs to present their accounts of the situation to be reflexive; consequently, they are less likely to be judgmental about others' ideas and more likely to find the best solution and develop innovative products. Therefore, the following propositions are:

Proposition P_5: Team reflexivity has a positive influence on the level of innovative work behaviors among NPD team members.

Proposition P_6: Team reflexivity has a positive influence on the level of product innovation and product performance.

The Effect of Innovative Work Behaviors

One major reason people innovate in the workplace is to bring performance gains (Yuan and Woodman, 2010). New technologies are introduced and new work methods are applied because these are "better" than the existing ones and are expected to bring performance improvement and efficiency gains. Such a belief in performance gains reflects the dominant efficiency-oriented perspective in the innovation literature, according to which the goal of technical efficiency guides innovation adoption and diffusion. Expected performance outcomes are positive when employees believe that their innovative behaviors will bring performance improvement or efficiency gains for their work roles or work units, particularly in NPD teams (Yuan and Woodman, 2010). They also suggested that innovative work behaviors lead to greater job satisfaction due to their personal orientation to be effective and efficient has been accommodated by the organization. Therefore, the following two propositions are developed.

Proposition P_7: Innovative work behaviors of NPD team members lead to greater job satisfaction.

Proposition P_8: Innovative work behaviors of NPD team members have a positive influence on the success of NPD.

The Effect of Individual Outcomes and NPD Success

According to affective events theory (AET - Weiss and Cropanzano, 1996), job satisfaction is a pleasurable or positive emotional state resulting from an individual's appraisal of their job, and

is the result of the employee perceptions of how well their job provides those things which they view as important. Moreover, satisfied employees have a favorable evaluation of their job, based on their observations and emotional experiences (Lum et al., 1998). As a result, these employees tend to perform favorable outcomes (Luthans, 1989). In the context of NPD, this study assumes that satisfied NPD team members will perform more innovative which then increase the performance of the product. As a result, the organizational performance also will be increased due to NPD team members' positive attitudes toward their organization.

Prior studies in NPD context never empirically discuss the influence of NPD success directly to organizational performance. As described by Weerawardena and O'Cass (2004) that innovative product is applying ideas that are new to the firm to create added value, either directly for the enterprise or indirectly for the customers. Moreover, product can be called innovative when there are new product advantage and product newness offered to the customers (Jordan and Segelod, 2006). As a result, it can be expected that NPD success directly influence to organizational performance through the increase of financial and market performance. Based on that, the following three propositions are developed:

Proposition P_9: The greater job satisfaction that NPD team members had, the higher NPD success will be.

Proposition P_{10}: Job satisfaction among NPD team members will contribute positively toward the organizational performance.

Proposition P_{11}: The innovativeness of the product and market performance will positively influence the organizational performance.

The Moderating Effect of Regulatory Focus

According to Higgins (1997), individuals have two basic self-regulation systems. One regulates the achievement of rewards and focuses individuals on promotion goals, while the other regulates the avoidance of punishments and focuses individuals on prevention goals. In the context of NPD teams, members who operate primarily within the promotion focus are more concerned with accomplishments and aspirations, use approach as a goal attainment strategy, are more creative in problem-solving processes, and show more willingness to take risks (e.g., Brockner and Higgins, 2001; Friedman and Forster, 2001). Moreover, Kark and Van Dijk (2007) indicate that the purpose of the promotion focus is to pursue development and change and to explore the advantage of creative and novel behaviors. Consequently, these members will have greater willingness to perform innovative work behaviors when they have greater promotion focus.

In contrast, members who operate primarily within the prevention focus are more concerned with duties and obligations, are likely to be sensitive to the presence or absence of punishments, and use avoidance as a goal attainment strategy (e.g., Crowe and Higgins, 1997; Friedman and Forster, 2001). Further, the purpose of the prevention focus is to assure one's

safety and security, to maintain routines, and to preserve the status quo. This study argues that members with prevention focus have less willingness to perform innovative work behaviors due to their avoidance attitude. Therefore, the following proposition is developed:

Proposition P_{12}: Regulatory focus will moderate the positive effects of (a) project management skills, (b) existing knowledge, and (c) project orientation on innovative work behaviors such that these positive effects will strengthen when the members has promotion than prevention focus.

The Moderating Effect of Task Familiarity

Previous studies seem to intuitively propose that familiarity with the task improves team performance; however, the empirical evidences are not so clear. Summarizing the mixed results in the familiarity literature, Harrison and colleagues conjectured that the effects of familiarity on team performance may differ depending on the nature of the task itself. Similarly, Argote and colleagues also concluded that the task matters when studying the effects of familiarity. Their experimental study shows that team performance increased with task experience and decreased with task complexity; performance on simpler tasks improved more strongly with task experience than on more complex tasks. This study argues that the positive effects of project management skills, existing knowledge, and project orientation on team reflexivity will be strengthened when the NPD team members are familiar toward their current tasks. Based on the above discussion, the following proposition is developed:

Proposition P_{13}: Task familiarity will moderate the positive effects of (a) project management skills, (b) existing knowledge, and (c) project orientation on team reflexivity such that these positive effects will be strengthened when the NPD members are more familiar with their current tasks.

The Moderating Effect of Procedural Justice

In addition, this study posits that the positive effects of team reflexivity and innovative work behaviors on new product success are strengthened when the NPD teams perceived that their management treated them fairly. The exchange theory posits that individuals will give back commensurately what they perceive to have received from the other party, through greater trust and accountability. Greater perceived procedural justice contributes to how individuals' inference about how much they need to trust the organization (Lind and Tyler, 1988). The greater perceived procedural justice, the more likely they are to trust the organization; this will interact with outcome favorability - work behaviors, such as developing innovative products. In other words, NPD teams make inferences about their perceptions of procedural fairness as a signal that the organization is trustworthy; and thus, teams respond positively by delivering favorable outcomes. Similarly, greater perceived procedural justice increase team members' inferences about how much they should hold the organization accountable for the outcomes that they receive. In other words, when NPD teams perceive that the procedures are unfair, they believe that the organization's accountability is high; and as a result, they will lower their initiatives and activities to deliver favorable outcomes. Consequently, it can be expected that

the positive effects of team reflexivity and innovative work behaviors on NPD success will be strengthened when the NPD team members perceived greater procedural justice. Based on these discussions, the following proposition is developed:

Proposition P_{14}: When project members perceive a higher level of perceived procedural justice, the positive effects of (a) team reflexivity and (b) innovative work behaviors on new product success is strengthened.

The Moderating Effect of Team Conflict

The previous discussion does not indicate under what conditions that the positive effect of team reflexivity and innovative work behaviors contribute more or less toward NPD success. Jehn (1995, 1997) noted that task conflict can be beneficial to task performance when working on nonroutine tasks, which are typically complex tasks without standard solutions, therefore requiring some consideration by the NPD team. Task conflict increases team members' tendency to elaborate task issues and to engage in extensive knowledge exchange regarding task-relevant information (Amason, 1996; Amason and Schweiger, 1997; Jehn, 1995, 1997). This fosters learning and the development of new and sometimes highly creative insights, leading the group to become more effective and innovative (Jehn, 1995). By experiencing task conflict, NPD team members will have greater team reflexivity and innovative work behaviors by the deep and deliberate processing of task-relevant information, during which the development of new and creative insights will be fostered leading the team to become more effective. Moreover, Simons and Peterson (2000) noted that groups who experience task conflict tend to make better decisions because such conflict encourages greater cognitive understanding of the issue being considered. As a result, it can be expected that when an NPD team has more team reflexivity and innovative work behaviors and at the same time experiences task conflict, the success of a newly developed product will increase.
In contrast, relationship conflict has only a detrimental role on team performance. The previous results have indicated that relationship conflict generally decreases satisfaction and interferes with task performance (e.g., Jehn, 1995, 1997; Amason, 1996). According to De Dreu and Weingart (2003), relationship conflict limits the information processing ability of an NPD team because each member spends his/her time and energy focusing on others rather than the assigned task. Consequently, it is expected that the positive effect of team reflexivity and innovative work behaviors on new product success will be weakened when the team members engage in relationship conflict. Based on this, the following two propositions are developed:

Proposition P_{15}: Task conflicts will moderate the positive effects of (a) team reflexivity and (b) innovative work behaviors such that these positive effects on new product success will strengthen when the members experience more rather than less task conflict.

Proposition P_{16}: Relationship conflicts will moderate the positive effects of (a) team reflexivity and (b) innovative work behaviors such that these positive effects on new product success will weaken when the members experience more rather than less relationship conflict.

CONCLUSION AND SUGGESTIONS

The primary aim of the current study, accordingly, is to emphasize the antecedents and consequences of innovative work behaviors and team reflexivity on NPD outcomes. This study regards team's ability for being reflexive is crucial to transform the members' knowledge and skills as well as teams' project orientation into innovative products. This study also considers innovative work behaviors as the crucial factor that determines NPD success. Similar to the antecedents of team reflexivity, this study proposes that members' innovative behaviors are determined project management skills, existing knowledge, and project orientation that NPD teams had.

Moreover, this study proposes that there are four moderators involved in this study. First, this study asserts that the relationships between project management skills, existing knowledge, and project orientation on innovative work behaviors have different magnitudes in different conditions. Second, this study proposes that the effects of antecedents of team reflexivity will be moderated by task familiarity. Third, this study proposes that the positive effects of team reflexivity and innovative work behaviors on new product success are strengthened when the NPD teams perceived that their management treated them fairly. Fourth, this study proposes that task conflict also serves as the moderator between innovative work behaviors and team reflexivity on the NPD outcomes.

Based on the above literature review, 18 propositions are developed that subject to further empirical validation. A preliminary research model is developed and shown in Figure 1.

Since the antecedents, moderators, and consequential variables of NPD team strain have not been comprehensively evaluated, it is expected that the results of this study can serve as a benchmark for academicians to further investigate this research issue. The study results will also be very useful for practitioners to design appropriate mechanism for the management of NPD team.

Based on the above research model, four contributions are expected to be delivered by this study:

1. This study has aimed to develop comprehensive sources of NPD team reflexivity and innovative work behaviors by proposing that project management skills, existing knowledge, and project orientation are the determinants. Further validations can enhance understanding on the role of these antecedents on NPD team operations.
2. This study has aimed to extend the concept of innovative work behaviors as the phenomenon inside NPD teams that will contribute to members', teams, and organizational outcomes. This study further argues that members will have innovative work behaviors when the team has sufficient time to reflect their current assignment. Thus, further validation on these research issues can provide valuable information for NPD management and for further academic validation.

3. Based on the suggestions of previous literature, this study proposed that regulatory focus, the familiarity level of NPD team toward the tasks assigned, their perception toward procedures being set up the management, and team conflict will serve as moderating variables. Further empirical validations could provide important references to human resources managers to develop the effective NPD teams to achieve better new product performance by integrating the consideration of these variables.
4. Previous scholars has proposed that a mixed study approach, which combined qualitative approach and quantitative approach in a research setting can largely improve the validity and generalizability of the study (e.g., Shah and Corley, 2006).

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CONSTRUCTING MODELS FOR EARLY CHRONIC KIDNEY DISEASE DETECTION AND RISK ESTIMATION

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ABSTRACT

In this paper, we aim to develop a best-fitting neural network model which can be employed to detect various severity levels of CKD based on the two different sets of influence factors as the inputs for model learning and developing. Firstly, the influence factors of CKD which most physicians employ in the computational formula are used as the inputs to three preselected fundament neural network models to detect (classify) various levels of chronic kidney disease. Secondly, the potential key influence factors of CKD which are identified by reviewing the CKD relevant literatures as well as conducting expert interviews are used as the inputs to three models as well. Three fundamental neural network models selected for detection and comparison include back-propagation network (BPN), generalized feedforward neural networks (GRNN), and modular neural network (MNN). Furthermore, three hybrid neural network models which are modeled by embedding genetic algorithm (GA) into each respective fundamental neural factor are employed for conducting CKD detection and comparison. The comparison among network models are based the CKD detection performance measured by the computation accuracy, sensitivity, and specificity in model training and testing.

The results of model experiment show that almost all models employed in experiment may gain near 100% accuracy in CKD detection in the training stage regardless of which sets of influence factors used in model training. However, if the model testing is further conducted, it is found that the network models with the inputs of influence factors of CKD used by physicians employed in the computational formula always shows better detection performance in all three aspects of measures. The BPN gain the highest 94.75% accuracy measures in the testing stage among three fundamental neural network models while GFNN gain only 86.63% in accuracy measure which is the lowest performance in three models. Through further observations from experiment results, it is found the hybrid network model of GFNN plus GA embedded may significantly enhance detection performance in all three measures from its fundamental model in the testing although the the detection performance are degraded in BPN and MNN.

We conclude that BPN might be the best-fitting factor Among three fundamental neural network models employed in detecting CKD while the models with GA embedded in BPN and GFNN respectively might be the best-fitting hybrid models for CKD detection.

Keywords: Chronic Kidney Disease, Disease Detection, Risk Estimation, Artificial Neural Networks, Genetic Algorithms.

INTRODUCTION

As people's life level become more and more modernized and life span become longer in our society, chronic kidney disease (CKD) becomes more common which may result in developing different levels of ill-function and damage of patient kidneys. Once a person gets CKD, he/she will suffer from the disease which may decrease his/her working ability as well as live quality. It is also very likely to develop other chronic diseases like high blood pressure, anemia (low blood count), weak bones and cause poor nutritional health and nerve damage. In the meantime, kidney disease increases patient risk of contracting heart and blood relevant diseases. Chronic kidney disease may be caused by other chronic disease such as diabetes, high blood pressure and other disorders. High CKD risk groups include those who have diabetes, hypertension, and family history of kidney disease. Early detection and treatment can often keep chronic kidney disease from getting worse. When kidney disease progresses, it may eventually lead to kidney failure which even requires dialysis or even proceeds to kidney transplant to maintain patient life.

According to the statistical data announced by the Department of Health of Taiwan's government in 2010 (DOH, 2010), the mortality caused by kidney disease has been ranked in the 10th place in all causes of death in Taiwan and thousands of others are at increased risk. The mortality caused from kidney disease is estimated as 12.5 in every 100,000 peoples. As a result, it costs as high as 35 percent of health insurance budget to treat the chronic kidney disease (CKD) patients with the age over 65 years old and end stage kidney disease patient in all ages. It occupies a huge amount of expenditures in national insurance budget.

Regarding to the measurement of serious levels of CKD, presently glomerular filtration rate (GFR) is the most commonly measuring indicators used in health institutions to estimate kidney health function. The physician in the health institution can calculate GFR from patient's blood creatinine, age, race, gender and other factors depending upon the type of formal-recognized computation formulas (Firman, 2009; NKF, 2002; Levey, 2005) is employed. The GFR may indicate how health of a patent's kidney and can be also taken to determine whether a people has kidney disease. The physician may also depend upon this indicator to determine the stage of kidney disease of a patient and help him to set a treatment plan for the patient (Firman, 2009; Levey et al., 2005).

The objectives of this paper aims to develop decision models by applying artificial neural networks and fuzzy expert system in artificial intelligence which attempts to provide physicians an alternative method to detect chronic kidney diseases and estimate the risk levels of a patient in early CKD stage. This study of this paper was cooperatively carried out with a district teaching hospital in New Taipei City located in the northern district of Taiwan.

In the first stage of this paper, we aim to develop a best-fitting neural network model which can be employed to identify various levels of CKD based on two different sets of influence factors as the inputs for model learning and developing. To reach this develop objective, firstly the set of influence factors of CKD which most physicians employ in the computational formula to diagnose CDK are determined for being used as the inputs to three preselected fundament neural network models. Next, another set of potential key influence factors of CKD which are identified by reviewing the CKD relevant literatures as well as conducting expert interviews are used as the inputs to three models as well. Three fundamental neural network models selected for detection and comparison include back-propagation network (BPN), generalized feedforward neural networks (GRNN), and modular neural network (MNN). Furthermore, three hybrid neural network models which are developed by embedding genetic algorithm (GA) into each respective fundamental neural factor Are employed for conducting CKD detection and comparison. The comparison among network models is based on the CKD detection performance measured by the measurement of factor Accuracy, sensitivity, and specificity respectively in model training and testing. The input data for the training, testing, and experiment of ANN models is collected from the people's health examination which is periodically carried out by collaborative hospital.

METHODS AND LITERATURES REVIEW

In this section, firstly the different methods of measuring CKD followed by two sets of influence factors used as the inputs for network modeling are reviewed. Next, the investigation of the criteria of CKD classification (i.e., detection) and risk evaluation of CKD is conducted. The three different neural network models employed for detection and comparison in this paper are surveyed and briefly introduced as well**.**

The Review of the Methods of Measuring Chronic Kidney Disease

The GFR is a most-commonly method used to measure kidney health function. It refers to the water filterability of glomerular of people's kidney. The normal value of measurement ought to be between 90 and 120 ml/min/1.73m^2. There are three common computation methods of GFR, which are (1) Removing rate of 24-hour urine creatinine (i.e., Creatinine Clearance Rate, Ccr) ; (2) Cockcroft-Gault formula (i.e., known as C-G formula) ; (3) Modification of Diet in Renal Disease formula (i.e., known as MDRD) (Firman, 2009). The CKD is categorized into five stages by making using of GFR to measure kidney function. Although the course of the change from stage one to five may usually last for years, it sometimes may enter into fifth stage pretty soon resulted in the necessity of dialysis or

kidney transplant (NKF, 2002; Levey et al., 2005).

Again, according to the guideline developed by the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative (KDOQI) (NKF, 2002), an independent not-for-profit foundation governed by an international Board of Directors in 2002 providing a new conceptual framework for a diagnosis of CKD independent of cause and developing a classification scheme of kidney disease severity based on the level of glomerular filtration rate (GFR). The new system represented a significant conceptual change, since kidney disease historically had been categorized mainly by cause. The diagnosis of CKD relies on markers of kidney damage and/or a reduction in GFR. Stages 1 and 2 define conditions of kidney damage in the presence of a GFR of at least 90 ml/min/1.73 m2 or 60 to 89 ml/min/1.73 m2, respectively, and stages 3 to 5 define conditions of moderately and severely reduced GFR irrespective of markers of kidney damage. The summarized of this guideline is shown in Table 1. The common definition of CKD has facilitated comparisons between studies. Thus, this new diagnostic classification of CKD has likely been one of the most profound conceptual developments in the history of nephrology. Nevertheless, there are limitations to this classification system, which is by its nature simple and necessarily arbitrary in terms of specifying the thresholds for definition and different stages. When the classification system was developed in 2002 (NKF, 2002; Levey et al., 2005), the evidence base used for the development of this guideline was much smaller than the CKD evidence base today. Therefore, this guideline is constantly revised from then on by Kidney Disease Outcomes Quality Initiative (KDOQI) with the modification and endorsement by Kidney Disease: Improving Global Outcomes (KDIGO). The currently available methods to estimate GFR and ascertain kidney damage are evolving (Levey et al., 2005).

Table 1: Classification of CKD as Defined by KDOQI and Modified and Endorsed by KDIGO.

Stage	**Description**	**Classification by Severity By GFR (ml/min/1.73m^2)**
1	Kidney damage with normal or GFR increasing	GFR >=90
2	Kidney damage with mild decreasing in GFR	GFR of 60-89
3	Moderate with decreasing in GFR	GFR of 30-59
4	Severe with decreasing in GFR	GFR of 15-29
5	Kidney failure	GFR <= 15 (or dialysis)

One of most recognized versions of the classification and risk evaluation of CKD was released by National Kidney Foundation (NKF) of US written by Firman in 2009 (Firman, 2009). Its severity classification and risk evaluation criteria are shown in Table 2 and 3, respectively. It is properly the most referable guideline regarding the classification and risk evaluation of CKD.

Table 2: Classification and Risk Evaluation of Chronic Kidney Disease.

Stage	**Description†**	**GFR *(ml per minute per 1.73 m^2)***	**Action plans**
-	At increased risk for chronic kidney disease	> 60 (with risk factors for chronic kidney disease)	Screening, reduction of risk factors for chronic kidney disease
1	Kidney damage with normal or elevated GFR	$\geq$ 90	Diagnosis and treatment, treatment of comorbid conditions, interventions to slow disease progression, reduction of risk factors for cardiovascular disease
2	Kidney damage with mildly decreased GFR	60 to 89	Estimation of disease progression
3	Moderately decreased GFR	30 to 59	Evaluation and treatment of disease complications
4	Severely decreased GFR	15 to 29	Preparation for kidney replacement therapy (dialysis, transplantation)
5	Kidney failure	< 15 (or dialysis)	Kidney replacement therapy if uremia is present

Table 3: Risk Factors for Chronic Kidney Disease and Definitions.

Type	Definition	Examples
Susceptibility factors	Factors that increase susceptibility to kidney damage	Older age, family history of chronic kidney disease, reduction in kidney mass, low birth weight, U.S. racial or ethnic minority status, low income or educational level
Initiation factors	Factors that directly initiate kidney damage	Diabetes mellitus, high blood pressure, autoimmune diseases, systemic infections, urinary tract infections, urinary stones, obstruction of lower urinary tract, drug toxicity
Progression factors	Factors that cause worsening kidney damage and faster decline in kidney function after kidney damage has started	Higher level of proteinuria, higher blood pressure level, poor glycemic control in diabetes, smoking
End-stage factors	Factors that increase morbidity and mortality in kidney failure	Lower dialysis dose (Kt/V)*, temporary vascular access, anemia, low serum albumin level, late referral for dialysis

*-In Kt/V (accepted nomenclature for dialysis dose), "K" represents urea clearance, "t" represents time, and "V" represents volume of distribution for urea.

In Taiwan, the Taiwan Society of Nephrology (TSN) also presented the self-detecting method of kidney for the public. The MDRD formula (Levey et al., 2000; Levey et al., 2005), which is recognized as a more accurate with mostly adopted method by kidney physicians to estimate glomerular filtration rate (GFR) from serum creatinine, is adopted for the use in diagnosis. Therefore, in this paper of study we also take MDRD to calculate the GFR. The method of calculation formula is shown in formula 1. The input data for the GFR calculation of each individual patient case in health examination are provided by the collaborative hospital of this research. We also use the calculated results as the desired (targeted) value to train our neural network models in experiment.

$$\mathrm{GFR} = 186 \times \mathrm{Creatinine}^{-1.154} \times \mathrm{age}^{-0.203} \left(\frac{\mathrm{ml}}{\frac{\mathrm{min}}{1}} . 73\mathrm{m}^2 \right) \ldots\ldots(1)$$

Note: For female the result should be multiplied by a factor of 0.742。

Snyder and Pendergraph (2005) indicated that the MDRD was suitable to be used to the group of diabetes mellitus, older age (age above 51), patient with kidney replacement

therapy (dialysis, transplantation). It also takes less number of factors than other two popular methods, which are Creatinine Clearance Rate computation and Cockcroft-Gault formula. It becomes easier and simple but still maintains the result effectiveness for calculating GFR. Hence, this paper adopts MDRD to conduct the calculation of GFR directly from the data collection of creatinine, age, and sex. The three factors, which are 'creatinine', 'age', and 'sex', considered in MDRD calculation also majorly compose the first set of input influence factors for modeling neural network models.

Artificial Neural Network

An artificial neural network (ANN), usually called neural network (NN), is a mathematical model or computational model that is inspired by the structure and/or functional aspects of biological neural networks. Kriesel (2011) indicates neural networks are a bio-inspired mechanism of data processing that enables computers to learn technically similar to human-being brain. The generic structure of ANN is shown in Figure 1 (Nagnevitsky, 2005). A neural network consists of an interconnected group of artificial neurons, and it processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external (input) or internal information that flows through the network during the learning phase. Modern neural networks are non-linear statistical data modeling tools. They are usually used to model complex relationships between inputs and outputs or to find patterns in data (http://en.wikipedia.org/wiki/Artificial_neural_network). It is properly the most prestigious and adoptable model in all application models in the field of artificial intelligence.

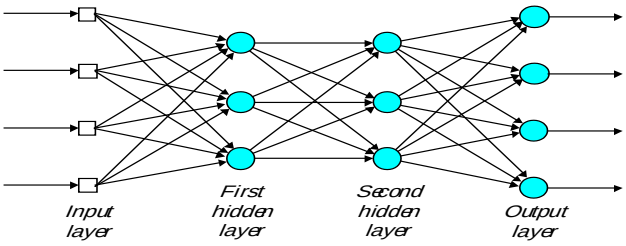

Figure 1: A Generic Structure of ANN.

There are many types of neural network models derived from the generic structure of ANN. Three fundamental neural network models employed for the experiment in this paper are briefly introduced in next sections

Back-Propagation Neural Network

The back-propagation neural network is aslo known as a "feed-forward back-propagation network". It is a supervising learning multi-layer perceptron (MLP) neural network model (Negnevitsky, 2005). A training set of input patterns is presented to the network. The network computes its output pattern, and if there is an error - or in other words a difference between actual and desired output patterns - the weights are adjusted to reduce this error. Since the real uniqueness or 'intelligence' of the network exists in the values of the weights between neurons, we need a method of adjusting the weights to solve a particular problem. It learns by example, that is, we must provide a learning set (or called as training set) that consists of some input examples and the known-correct output (desired output) for each case. So, we use these input-output examples to show the network what type of behavior is expected, and the back-propagation learning algorithm allows the network to adapt. Hence, this neural network is called as back-propagation neural network (BPNN). A three-layer architecture of BPNN is illustrated in Figure 2 (Negnevitsky, 2005).

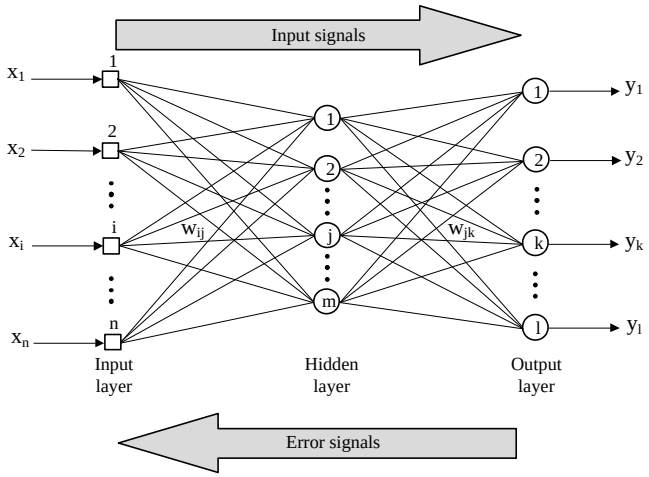

Figure 2: Three-layer Back Propagation Neural Network.

This model is properly the most popular and applicable model in artificial neural network used in academic research and the development practical decision support applications in terms of forecasting, classification, regression, data mining, and so on.

Generalized Feedforward Neural Network

The feedforward neural network was the first and arguably most simple type of artificial neural network devised. In this network the information moves in only forward direction which is simply from the input neuron data goes through the hidden neuron and to the output nourons. There are no cycles or loops in the network where the data flow from input

to output units is strictly feedforward. The data processing can extend over multiple layers of neurons, but no feedback connections are present. Its generalization model, which is konwn as generalized feedforward neural networks (GFNN). It has the same architecture as back-propagation neural network and also adopts the same learning methods to train the network. The differences are that GFNN adopts generalized distributed-flow neurons in its hidden layers and take perceptron as its inhibitory neuron. Arulampalam and Bouzerdoum (2000) mentioned that the GFNN architecture used as the basic computing unit is a generalized shunting neuron (GSN) model which includes as special cases the perceptron and the shunting inhibitory neuron. GSNs were capable of forming complex, nonlinear decision boundaries. This allows the GFNN architecture to easily learn some complex pattern classification problems. Arulampalam and Bouzerdoum (2003) applied GFNNs to several benchmark classification problems, and their performance was compared to the performances of multilayer perceptrons such as a back-propagation neural network. Experimental results show that a single GSN can outperform multilayer perceptron networks. An exemplified architecture of GFNN is illustrated as Figure 3.

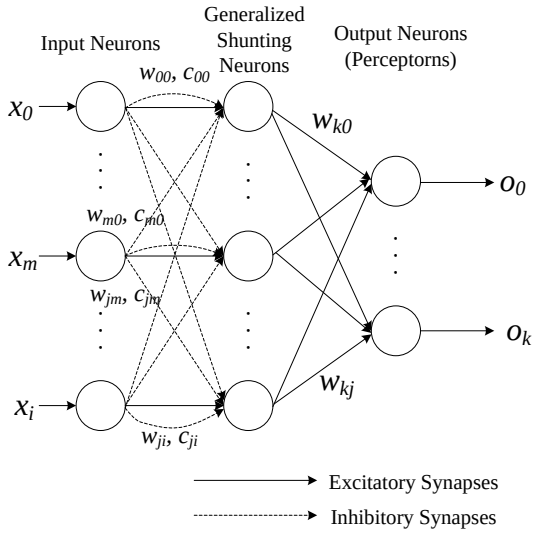

Figure 3: The Generic Architecture of Generalized Feedforward Neural Networks.

Modular Neural Network

The modular neural network (MNN) was initially presented by Jacobs, et al. in 1991 (Jacobs et al. 1991). The architecture of this network is shown in Figure 4. It is characterized by a series of independent neural networks moderated by some intermediary. Each independent neural network serves as a module like an expert and operates on separate inputs to accomplish some subtask of the task the network hopes to perform. The intermediary takes the outputs of each module and processes them to produce the output of the network as a whole (Azam, 2000). The intermediary only accepts the modules' outputs—it does not

respond to, nor otherwise signal, the modules. As well, the modules do not interact with each other. One of the major benefits of a modular neural network is the ability to reduce a large, unwieldy neural network to smaller, more manageable components. There are some tasks it appears are for practical purposes intractable for a single neural network as its size increases.

The following are benefits of using a modular neural network over a single all-encompassing neural network.

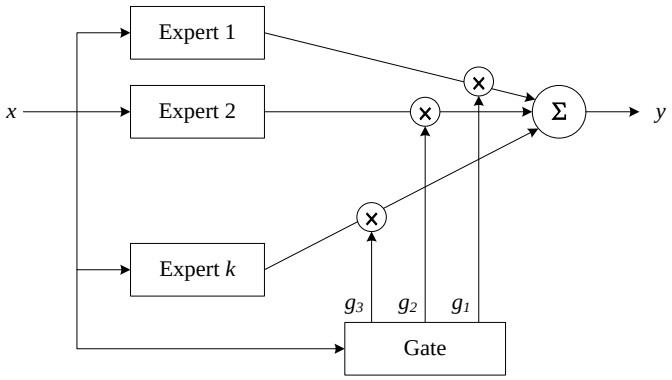

Figure 4: The Generic Architecture of Modular Neural Networks.
(Source: http://en.wikipedia.org/wiki/Modular_neural_networks)

RESEARCH MATERIALS AND METHODS

Based on the literature reviews and expert interviews, this research takes three neural network models, back propagation neural network, feedforward neural network, and modular neural network, respectively to generate the detection model for chronic kidney disease. The input data set for neural networks training and testing are collected from the population data of health examination provided by collaborative hospital. The key influence factors input for the each factor Are determined and verified from professional kidney experts and physicians. The set of influence factors derived from GFR computation formulas such as MDRD is shown in Table 4 and another set of key influence factors selected and determined in this paper as the inputs of Neural Networks is shown in Table 5, respectively. The classification performance of two sets input for model training and testing are compared in model experiment.

Table 4: The Influence Factors Derived from Formula Computation for GFR.

Factors	Description	Mean	Maximum	Minimum
Sex	0→Female;1→Male	---	---	---
Age	Integer	77.38	93	67
Creatinine	Real	0.88	4.28	0.37
Weight	Real	60.719	98	32
GFR Levels	0→Negative;1, 2, 3,4,5→Positive measured in levels	---	---	---

Table 5: The Influence Factors Investigated Determined by This Paper.

Factors	Description	Mean	Max.	Min.
Creatinine	Real	0.88	4.28	0.37
Glucose (GLU)	Real	109.63	271	82
Systolic Pressure (SP)	Real	135.78	195	88
Protein in Urine (UP) or called proteinuria	0→Negative 1→Trace; 2→+ 3→++; 4→+++	---	---	---
Hematuria		---	---	---
Blood Urea Nitrogen (BUN)	Real	15.80	80.1	5.4
GFR-Level	0→Negative;1, 2, 3,4,5→Positive measured in levels	---	---	---

The Learning Data and Preprocessing

The input learning data set for neural networks are collected and sampled from the cases of the elderly people with age over 65 years old of health examination provided by collaborative hospital in past few years. The areas of sampled data cover the hospital neighboring cities and counties located in northern part of Taiwan. There are 1161 heath examination case records are sampled. Before they are input for training and testing network models, a data preprocessing is processed to remove duplicate, correct the error, inconsistency and missing fields, numerification of class field in each case record.

By this process, we can ensure the accuracy, completeness and integrity of the input data. After data preprocessing, only 945 sampled cases are left as the use of learning data set. Meanwhile, initially there are 21 fields contained in each source of case record. Only 6 fields specified in Table 5 are selected and maintained for each case.

Model Learning and Experiments

We take NBuilder of neural solution, a well-known neural network modeling tool, to train and test our neural network model through a series of simulations in experiment. In consideration of the tool restriction for building the hybrid model of neural network and genetic algorithm which is also studied in this research, we only take the most accurate 430 cases from 945 sampled cases left after preprocessing in learning process. By this selection, we can ensure there are equal numbers of cases used in the leaning process of each factor Building. As it is shown in Table 6, among 430 cases, 300 cases are selected for training, 100 records are used for testing, and 30 cases for cross verification. The desired output of diagnosis is identified by the professional physicians of chronic kidney disease from the collaborative hospital with the aid of MDRD calculation formula.

Table 6: Data Distribution for Model Training, Testing, and Cross Verification.

Sampled Data	**Record #**	**Desired Output #**
Training Data	300	101 Negative
		199 positive in various levels
Testing Data	100	34 negative
		66 positive
Cross Verification	30	10 negative
		20 positive

EXPERIMENTS AND COMPARISONS OF NEURAL NETWORK MODELS

The experiment for a specific network model can be viewed as a series of modeling and simulation through leaning process. We attempt to pursue a best model through the selection of different combination of modeling parameters for conducting learning in different network models. The parameters combination shown in different model experiments have been filtered from a series of learning process.

The Experiment of Back-propagation Neural Network

Table 7 shows the parameters set for the experiment of back-propagation neural network.

Table 7: Parameters Selected for Back-propagation Neural Network.

Parameters	**Value Setting**
# of Hiding Layers	1、2、3
# of Neurons in Hiding Layer	5、8、12
Learning Rules	Step、Momentum、ConjugateGradient、LevenbergMarquar、Quickprop、DeltaBarDelta
Transformation Functions	TanhAxon、SigmoidAxon、LinearTanhAxon、LinearSigmoidAxon、SoftMaxAxon、BiasAxon、LinearAxon、Axon
Weight Update Methods	Batch
Criterion for Termination	MSE_{min}:0.0001; $Epochs_{max}$:3000

In this paper, we also take the hybrid models of combining each neural network factor And genetic algorithm (GA) in experiment and comparison. The model parameters selected for genetic algorithm are shown in Table 8. GA will be taken to combine with back-propagation neural network, feedforward neural network, and modular neural network, respectively in model experiment and comparison as well.

Table 8: The Parameters Selected for Genetic Algorithm.

Network Parameters	**Value Setting**
Method of Selection	Roulette
Method of Crossover	One Point
Rate of Crossover	0.9
Rate of Mutation	0.01
Termination Criterion	MSE_{min}:0.0001 $Epochs_{max}$:100 Population: 20 Generations：50

Through a series of simulation by taking the different sets of parameter combination selected from Table 7, we gain that the best model of backpropagation neural network in terms of their respective network parameters with respect to two models, which are the factor By adopting the key factors used in computation formula (called as Factor A hereafter) and the factor By adopting the key factors selected in this paper (called as Factor B

hereafter), respectively, are listed in Table 9. The classification accuracy, sensitivity, and specificity with respect to factor A and B, respectively is shown in Table 10.

Table 9: The Best Models with Backpropagation Network Parameters Setting.

Network Parameters	**By Adopting the Key Factors Used in Computation Formula (Factor A)**	**By Adopting the Key Factors Selected in This Paper (Factor B)**
Learning Rule	LevenbergMarquar	LevenbergMarquar
Transformation Functions	TanhAxon	SigmoidAxon
# of Hiding Layer	2	2
# of Neurons in Hiding Layer	5	8
Criterion for Termination	MSE_{min}:0.0001 $Epochs_{max}$:3000	MSEmin:0.0001 Epochsmax:3000
Methods for Weight Update	Batch	Batch

Table 10: The Experiment Results from Backpropagation Neural Network Models.

BPN	**Factor A**		**Factor B**	
Pure BPN	Training	Test	Training	Test
Accuracy of Classification	100%	94.75%	100%	72.42%
Sensitivity	100%	97.06%	100%	70.59%
Specificity	100%	92.42%	100%	74.24%
BPN+GA	**Test**		**Test**	
Accuracy of Classification	91.71%		77.68%	
Sensitivity	97.06%		81.82%	
Specificity	86.36%		73.53%	

In Table 10, “accuracy” is used to measure the classification accuracy with the proportion of the sum of the number of true positives and the number of the true negatives which are correctly identified. “Sensitivity” is used to measure the proportion of actual positives which are correctly identified as such (e.g. the percentage of sick people who are correctly identified as having the condition). “Specificity” is used to measure the proportion of negatives which are correctly identified (e.g. the percentage of healthy people who are correctly identified as not having the condition). These two measures are closely related to the concepts of type I and Type II. From the results shown in Table 10, our experiment may gain very good results with BPN in model training stage but it shows a significant drop

measured in model testing stage both with BPN and BPN plus GA. By the results shown in Table 10, BPN may obtain better results in accuracy measure, but GPN plus GA gain better result in sensitivity measure. The result also shows the model with the adoption of the key factors used in computation formula gains better results in all three indicators measures. These results tell us that a hybrid model with the combination of BPN and GA does not improve the model performance in accuracy measure but it is helpful to improve sensitivity measure.

The Experiment of Generalized Feedforward Neural Network

Table 11 shows the parameters set for the experiment of generalized feedforward neural network (GFNN). The classification accuracy, sensitivity, and specificity with respect to factor A and B, respectively is shown in Table 12. As the results shown in Table 12, pure GFNN obtain a perfect classification percentage in three measures including accuracy, sensitivity, and specificity in training stage, but GFNN plus GA apparently may gain better results in testing. However, they also show the results gained from GFNN are not so good in all three measures as those gained from BPN and BPN plus GA, respectively.

Table 11: The Best Models with Generalized Feedforward Neural Network Parameters Setting

Network Parameters	**Factor A**	**Factor B**
Learning Rule	LevenbergMarquar	LevenbergMarquar
Transformation Functions	SigmoidAxon	TanhAxon
# of Hiding Layer	2	2
# of Neurons in Hiding Layer	8	8
Criterion for Termination	MSE_{min}:0.0001 $Epochs_{max}$:3000	MSE_{min}:0.0001 $Epochs_{max}$:3000
Methods for Weight Update	Batch	Batch

Table 12: The Experiment Results from Generalized Feedforward Neural Network Models

GFNN	**Factor A**		**Factor B**	
Pure GFNN	**Training**	**Test**	**Training**	**Test**
Accuracy of Classification	100%	86.63%	100%	71.03%
Sensitivity	100%	82.35%	100%	61.76%
Specificity	100%	90.91%	100%	80.30%
GFNN+GA	**Test**		**Test**	
Accuracy of Classification	91.09%		78.39%	
Sensitivity	88.24%		76.47%	
Specificity	93.94%		80.30%	

The Experiment of Modular Neural Network

Table 13 shows the parameters set for the experiment of modular neural network (MNN). The classification accuracy, sensitivity, and specificity with respect to factor A and B, respectively is shown in Table 14. As the results shown in Table 13, pure MNN same as prior two models which may obtain a perfect classification percentage in three measures in training stage, but MNN plus GA apparently may gain worse results in testing stage which are different from the results shown in prior two models.

Table 13: The Best Models with Modular Neural Network Parameters Setting.

Network Parameters	**Factor A**	**Factor B**
Learning Rule	LevenbergMarquar	LevenbergMarquar
Transformation Functions	SigmoidAxon	SigmoidAxon
# of Hiding Layer	2	2
# of Neurons in Hiding Layer	4	8
Criterion for Termination	MSE_{min}:0.0001 $Epochs_{max}$:3000	MSE_{min}:0.0001 $Epochs_{max}$:3000
Methods for Weight Update	Batch	Batch

Table 14: The Experiment Results from Modular Neural Network Models.

MNN	**Factor A**		**Factor B**	
Pure MNN	**Training**	**Test**	**Training**	**Test**
Accuracy of Classification	100%	93.23%	100%	70.99%
Sensitivity	100%	97.06%	100%	64.71%
Specificity	100%	89.39%	100%	77.27%
MNN+GA	**Test**		**Test**	
Accuracy of Classification	88.82%		78.34%	
Sensitivity	89.39%		79.41%	
Specificity	88.24%		77.27%	

CONCLUSIONS

The performances of three neural network models developed for comparison in this paper in terms of detection (i.e., classification) accuracy measure are summarized and shown in Table 15 and 16, respectively. Table 15 shows the detection accuracy in three pure (i.e., fundamental) neural network models while Table 16 shows the detection accuracy with GA embedded in three respective models. We found BPNN may obtain best accuracy regardless of in factor A or in factor B which are measured with 94.75% and 72.42% accuracy, respectively in model testing. However, factor A, which is the test by adopting the key factors used in computation formula, may gain much better performance than factor B, which is the test by adopting the key factors selected in this paper. The same result is gained with the GA embedded in each fundamental model in experiment. As the results observed from Table 16, both BPN plus GA and GFNN plus GA gain close results in accuracy measure which is much better than MNN plus GA.

Table 15: Detection Accuracy in Three Pure Neural Network Models.

Network Models	**By Adopting the Key Factors Used in Computation Formula (Factor A)**	**By Adopting the Key Factors Selected in This Paper (Factor B)**
BPN	94.75%	72.42%
GFNN	86.63%	71.03%
MNN	93.23%	70.99%

Table 16: Detection Accuracy in Three Pure Neural Network Models Plus GA.

Network Models	**Factor A**	**Factor B**
BPN+GA	91.71%	77.68%
GFNN+GA	91.09%	78.39%
MNN+GA	88.82%	78.34%

By further observation from the results of model experiment shown in section 4, it is found that almost all models employed in experiment may gain near 100% accuracy in CKD detection in the training stage regardless of which sets of influence factors used in model training. However, if further model testing is conducted, it is found that the network models with the inputs of influence factors of CKD used by physicians employed in the computational formula always shows better detection performance in all three aspects of measure including accuracy, sensitivity, or specificity measures. The BPN gain the highest 94.75% (shown in Table 10 and 15) accuracy measure in the testing stage among three fundamental neural network models while GFNN gains only 86.63% (shown in Table 12 and 16) in accuracy measure which is the lowest performance in three models. Through further observations from experiment results, it is found the hybrid network model of GFNN plus GA embedded may significantly enhance detection performance in all three measures from its fundamental model in the testing although the reversed enhancement are shown in BPN and MNN. Again, by the experiment figures shown in section 4, although pure neural network models plus GA shows degraded performance improvement for factor A in testing stage in terms of three measures in accuracy, sensitivity, and specificity but it shows significant improvement for factor B. As a result, we conclude a hybrid model indeed may improve detection performance. This result may conclude that GA provides no benefit in the yield of better detection performance with the adoption of the key factors used in computation formula as the inputs to all models in testing.

Above all, we conclude that BPN might be the best-fitting factor Among three fundamental neural network models employed in detecting CKD while the models with GA embedded in BPN and GFNN respectively might be best-fitting hybrid models for CKD detection but only GFNN plus GA can gain enhancement in detection performance in both sets of influence factors as inputs. These conclusions should be further verified and compared with other models selected for experiment in later studies before they can be assured.

We believe that the neural network models respectively developed for CKD detection and risk level estimation in this paper may equip medical staff with the ability to make precise diagnosis and treatment to the patient. Meanwhile, public users may take advantage of these system instruments to conduct self-detection of the risk level of causing CKD in order to take necessary precaution in advance to avoid any risk of causing CKD or prevent their condition from getting worse.

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F1 – Performance Management

F1.1 **A competitive operative management system in the electronic manufacturing business**
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A COMPETITIVE OPERATIVE MANAGEMENT SYSTEM IN THE ELECTRONIC MANUFACTURING BUSINESS

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ABSTRACT

The purpose of this case study is to create a competitive operative management system to enable efficiency and quality performance in a mid-sized electronic manufacturing company, and the product and service creation process for the globally competitive electrical markets.

Sense and Respond, a multi-criteria decision making method is used as a tool in this study, in order to define the most critical development areas in the business process redesign and quality, especially COPQ (Cost of Poor Quality) point of view.

A qualitative research method with multi-criteria decision making process has been created and utilized in order to collect data through in-depth expert interviews. The performance measurement and improvement system developed has been implemented into practice in the case company.

Keywords: performance management, multi-criteria decision making, competitiveness, quality, electronics manufacturing industry, production, product and service creation.

INTRODUCTION

The purpose of this study is to find the most critical areas of the quality development needing improvement. Quality in this study is considered as a companywide examination, all main processes and main functions are covered.

The Case organization had recognized a need for an investigation of the process re-engineering concerning customer closeness and COPQ (Cost of Poor Quality) issues. Another matter that organization had considered was the role of the functions in relation to the key processes and also how well the current key processes correspond to the current way of action.

The research theory is based on the method introduced by Takala and Rautiainen and later Ranta and Takala, providing a tool to measure and indicate the most critical development areas. The method measures responder's expectations and experiences of quality and process related issues. Difference between expectations and experiences together with the deviation of the answers determines the so called critical factors index. The critical factor index calculation is utilized by the methods presented later in this study. The critical factor index indicates the most critical areas that need further development and respectively

indicates also areas that have enough actions. A questionnaire has also a part where the direction of the development is measured and this information is taken into account in a statistical calculation. Also the direction of the development of individual aspects is taken into account (Rautiainen, Takala, 2003; Ranta, Takala, 2007).

The data regarding the current situation of quality and process was collected through interviews with the case-company's employees. People of the organization that took part in the questionnaire, have been chosen on the principle that they represent either management function or expert function. The case-company, ABB Oy, Distribution Automation Finland (ABB/DA/FI), is a company which provides numerical protection relays for international markets wordwide.

The results of the research identify critical development areas of the organization. The results are not unambiguous and require interpretation. The results of the study have been considered through the experience of responders, the view points between different groups of responders and also the answers between different groups.

CUSTOMER SATISFACTION AND QUALITY STRATEGIES FOR THE ELECTRONIC MANUFACTURING BUSINESS

Numerical Protection Relay are considered as Intelligent Electronic Device (IED), which consists of electronics parts, such as analog and digital input and output device, large scale of different communication modules and intelligent software. An IED is placed in an operational usage part of a larger electrical distribution network or power systems in order to measure and control operations in a way that all abnormal situations are controlled according to pre-programmed parameters and intelligent software control (ABB, 2011).

ABB's Relion® product family consists of several product series, which cover a wide range of protection, control, measurement and supervision of power systems (ABB, 2011).

Quality is one of the key stones in the Electronic Manufacturing Business. The competitive advantage of a company depends on the quality of the manufactured IEDs, design of electronics and software of the IED, and the interface between other parts of the electric power network or power system devices (ABB, 2011). The Certified Quality Handbook categorized quality in Management and Leadership, The Quality System, Product and Process Design, Product and Process Control, Continuous Improvements and Quantitative Methods and Tools (Kubiak and Benbow, 2008). Quality is a diverged concept in a general point of view. Sometimes a simple question of "what is quality" is presented. Nowadays customer satisfaction is one of the paradigms that drive company actions. The research results indicate that quality conformance has a significant impact on the customer satisfaction (Maiga, 2004). Based on this, quality would be defined as follows: Quality is defined through customer's satisfaction. Kumar (S C Chen) & al represent in their article that a better customer satisfaction and business profit can be achieved by the high level product design, effective manufacturing and high level of service quality (Kumar et al 2009, 3). Gordon writes in his article as follow: "*Product delivery is the culmination of all of the business processes, and output is a measure of system capability*"(Gordon, 2008, 2). This has

to be taken into account during optimizing of all processes instead of falling for sub-optimization.

Quality Tools serve many kinds of purposes. The case company has recently focused on the 4Q and 5S quality tools. 4Q is a problem solution tool, which brings a systematic way of actions in quality improvement. 4Q is an ABB internal quality tool which is quite close to the Deming PDCA –circle. The 4Q method consists of a four step circle: Measure, Analyze, Improve and Sustain (Praveen 2006). 5S is a systematic quality tool that consists of five stages following each other: 1. Sorting 2. Simplifying 3. Self-discipline 4. Sweeping and 5. Standardizing. The case company has a whole organization wide systematic implementation of the 5 S tool (Becker, 2001).

Total Quality Management is considered here as a company wide way of actions in all level of organizational actions. Definition for the Quality management according to the Enterprise Performance Management (2009): *"A management system that seeks the efficient achievement of the stakeholder expectations by focusing the efforts of every member of the organization on customer satisfaction and by using quality techniques in each of the sub - systems of the organization"* (EPM, 377).

Total Quality Management has two functional levels, a strategic and an operational level, and a third tactical level between. Based on "A Grounded Theory Research Study of Strategic Dynamics of Total Quality Management" (Leonard and McAdam, 2002; Leonard and McAdam, 2003), it can be founded on the above mentioned strategic drivers model for Total Quality Management, which is presented in Figure 1.

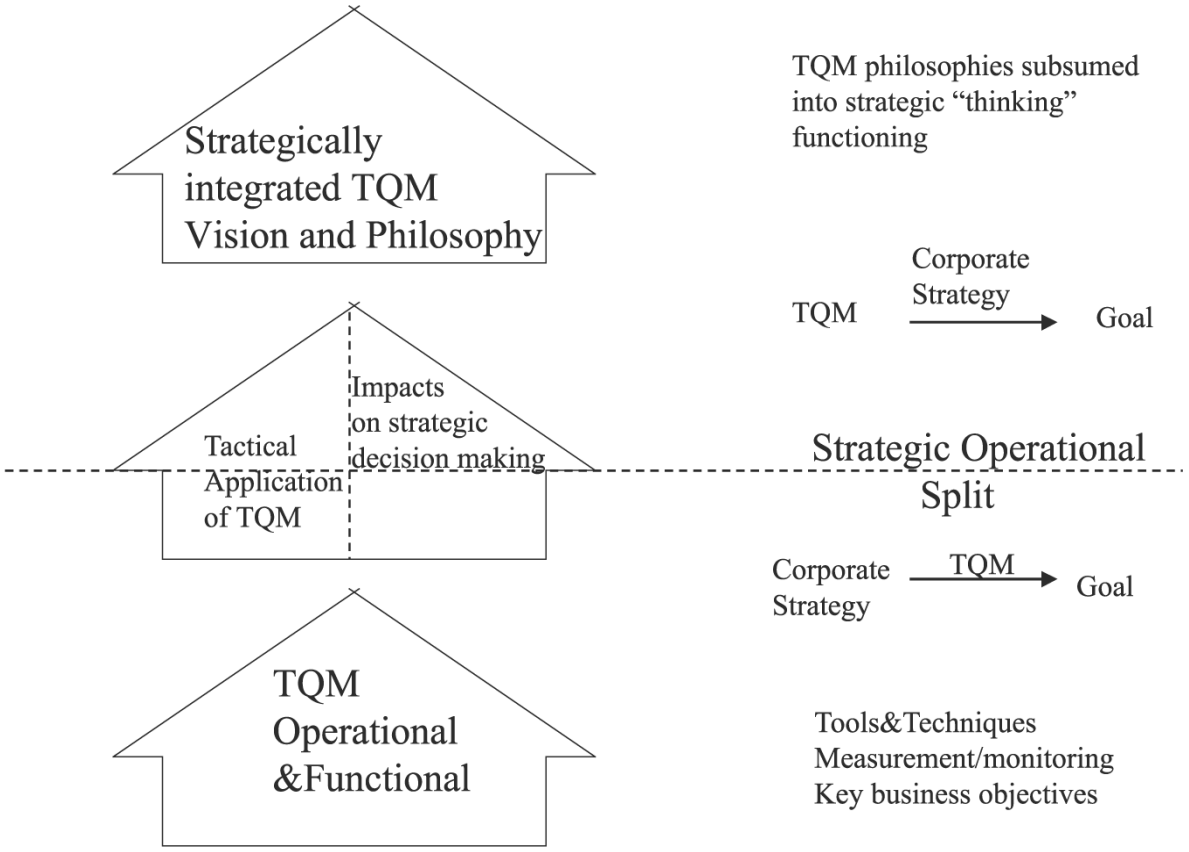

Figure 1: Strategic driver model for Total Quality Management (Leonard, McAdam, 2003).

Total Quality Management is basically a wholeness of how organization has organized its operations at the strategic level, for example a guideline of a matrix organization, where all the core actions of the company management are defined. Leonard and McAdam have defined a term “An Evaluative framework for TQM dynamics”, where the effect and dynamics of TQM in the organization are analyzed (Leonard and McAdam, 2003). Quality Management practices have a positive influence on the customer satisfaction, removing barriers between the individuals and departments, ensuring the company to achieve better productivity and business performance (Terziovski, 2006, 9). Markku Tinnila considers in his article the difference between Quality Management and Business Process Redesign. He argues that they both tend to improve efficiency and quality. Quality management improves through the TQM activities that company has, while Business Process Redesign covers also the definition of new ways of actions that have not been taken into account before (Tinnilla 1995, 4).

Business Process Redesign (BPR) is performed in order to achieve considerable improvements in the performance (Kallio et all 2002, 1). BPR has to be performed in an integrative and holistic way. Important aspects are processes, technology, organization structure, relationship and culture. The BPR definition is not unambiguous. There are different aspects of BPR. Some authors prefer more the customer aspect focusing on activities to provide adding value for the customer, while others prefer more process and measures of the activities varying according to the business area and the specific situation of a company. (Al-Mashari et all 2001, 1-3; Hustic 2009, 1-2). Tinnila emphasizes the importance of Information Technology (IT) as an enabler of the strategic planning and observation of the potential of BPR. The notion of functional departments and processes similarities is seen as an obstacle in the BPR performing (Tinnila 1995, 1).

When considering BPB activities, the company has to define, which particular part of the business process needs renewal and further more, what method should be used. It is quite common that the company has to resort to some external consultation (facilitator) during the BPR activities. The methods used during the consultation are based on experience or wisdom of best practices of the consultation partner (Mansar et all 2007). According to the article of Tom Dolan, benchmarking is the most common tool in the process improvement. Among other popular methods are cause and effect, analyze, change management, control charts and decision making. Besides the suitable methods, the company has to identify the main problem and how it effects matters such as customer satisfaction, employee involvement and financial returns. More significant issues in BPR are a visible top management support, effective and working cross functional team with enough wide representation of different parts of the organization and effective communication in all levels of the organization (Dolan et all 2003, 1-4).

When considering BPR in order to increase the company competitiveness, BPR has to be directed towards the strategic position. According to Si *et al.* (2008), quality, customer focus and know-how are the three most important factors of the competitive priorities of manufacturing strategy. (Si et al 2008, 4). According to the authors, there are four fundamental processes: technical, innovation, enabling and social, on which the company has to focus during business process re-engineering or redesign (Tinnilla 1995, 2).

Process organization is considered in this study as a business process, a companywide way of actions. The process in this case is defined as follows: Activity process is a group of logical operations and recourses to perform these actions in order to create results of the activities (Laamanen 2001).

Customer closeness is considered as well one of the key success factors during improving quality. Especially this has to be taken into account when a new expedient has to been found in order to find a way of action to improve ability to create added value for the customer. When considering the similarity between TQM, Six Sigma and Lean, one common denominator is customer satisfaction. All of these viewpoints tend to increase customer satisfaction by minimizing waste and resources (Andersson et al, 2006, 2-4).

BUILDING THE METHOD

The research method is mostly a case study in order to focus in one case company, but it also has the features of empirical, weak market test and constructive methods. Empirical material based on the questionnaire performed in the case company. The weak market test features represented by the question of how the implemented research methods suit to define the efficiency and quality performance for a company in a mid- sized electronic manufacturing business. A constructive method in this study represents the performed research method "Sense and Respond multi-criteria decision making". The method used is performed in the same format as in earlier study in the literature, and this study does not contain any new application of the above mentioned research method.

The research theory is based on a method introduced by Rautiainen and Takala, which is a tool to measure the quality of service. Based on the calculated percentage values compared with competitors and direction of development, it measures expectations and experiences of the organization performance. The gap between the expectations and experiences, the direction of development and importance are calculated. Importance index measures the importance and pressure to improve (Rautiainen, Takala, 2003; Ranta, Takala, 2007).

The tools contain several indexes calculated from the results of the questionnaire. These tools are used to gain a more overall interpretation of the results. The research method includes averages and standard deviations calculation for all the measured attributes of the expectations and experiences. Standard deviations help to evaluate the validity and reliability of the results. Percentual figures are calculated from direction of the development and compared with competitors. Ranta and Takala have developed the Critical Factor Index (CFI). This index takes also the standard deviation of the expectations into account. The factors in the devisor are Importance index, which are the average of importance divided by ten, Gap index which measures the gap between the expectations and experiences and the Direction of development index (Rautiainen, Takala, 2003; Ranta, Takala, 2007).

$$CFI = \frac{\text{standard deviation of expectation} * \text{standard deviation of experience}}{\text{Importance index} * \text{Gap index} * \text{Direction of development index}}$$

Figure 2: CFI, Critical Factor Index (Rautiainen, Takala, 2003).

The first step of the used research method was to create a questionnaire that gathers the responder's opinions. Each attribute was evaluated in four different ways: expectation, experience, compared with competitors and direction of development compared with time scale of 1 year and 2 years ago. To ensure that the reliability and validity was high, the questionnaire was short, clear and easy to answer. The more comfortable the questionnaire is to answer, the more reliable and valid the answer is. Rautiainen & Takala used a simple numerical estimation scale ranging from 1 to 10. The wide scale ranging from 1…10 makes it easy to find differences between the attributes. Figure 3 introduces how the information was gathered (Rautiainen, Takala, 2003).

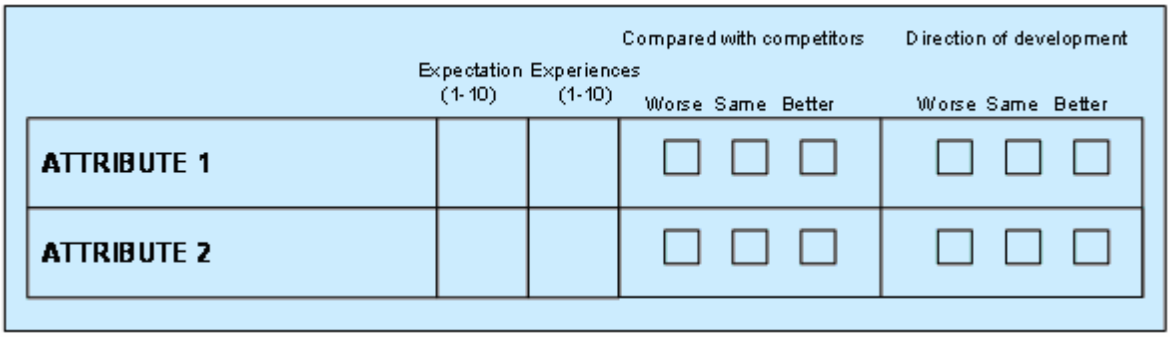

Figure 3: Questionnaire (Rautiainen, Takala, 2003).

The Attributes were categorized under four main categories: Process Capability with nine attributes, Product Capability with six attributes, Personnel Capability with five attributes, and Measures KPI's current status with nine attributes, all together 29 attributes. The four main categories mentioned represent the research area of the study. The questionnaire was executed via email by using an Excel form especially created for this purpose.

RESULTS

The questionnaire was directed to the experts and management for the following functions: Management, Operations, R&D department, Product and Portfolio Management, Sales & Marketing, Customer Support and Other Management. The questionnaire was delivered to 48 persons and 24 answers were received. The questionnaire was delivered by email. Answers' reliability would be increased by a personnel interview instead by sending it by email and this has to be considered in future for similar questionnaire. The answers are divided in to subgroup as follows (answers got / answers sent): Management 4/7, Operations 4 / 7, R&D 5 / 11, Product Portfolio Management 3 / 6, Sales&Marketing 2 / 8, Customer Support 4 / 8 and Other Management 2 / 8. Due to the partly low scope of the answers, Sales&Marketing and Other Management departments are left out of the department specific study. The scope of the rest department is also low, so only an indicative conclusion can be done whereas group all (24 / 48) has enough scope and statistical conclusions to be reliable.

95 % confidential level has calculated from all results according Table 1.

Proc#1	Experiences	5,86	< P(n) <	7,32		Expectations	8,59	< P(n) <	9,41
Proc#2	Experiences	6,73	< P(n) <	7,71		Expectations	8,86	< P(n) <	9,48
Proc#3	Experiences	6,29	< P(n) <	7,35		Expectations	8,59	< P(n) <	9,41
Proc#4	Experiences	5,14	< P(n) <	6,94		Expectations	7,53	< P(n) <	8,73
Proc#5	Experiences	5,74	< P(n) <	7,22		Expectations	7,81	< P(n) <	8,80
Proc#6	Experiences	6,53	< P(n) <	7,73		Expectations	8,34	< P(n) <	9,14
Proc#7	Experiences	6,32	< P(n) <	7,78		Expectations	8,15	< P(n) <	9,22
Proc#8	Experiences	4,57	< P(n) <	6,21		Expectations	7,76	< P(n) <	8,76
Proc#9	Experiences	5,96	< P(n) <	7,49		Expectations	7,70	< P(n) <	8,67
Prod#1	Experiences	6,40	< P(n) <	7,78		Expectations	8,99	< P(n) <	9,71
Prod#2	Experiences	7,00	< P(n) <	8,04		Expectations	8,91	< P(n) <	9,61
Prod#3	Experiences	7,28	< P(n) <	8,20		Expectations	9,72	< P(n) <	10,02
Prod#4	Experiences	7,16	< P(n) <	8,65		Expectations	8,44	< P(n) <	9,27
Prod#5	Experiences	5,91	< P(n) <	7,22		Expectations	7,81	< P(n) <	8,88
Prod#6	Experiences	6,14	< P(n) <	7,69		Expectations	8,01	< P(n) <	8,95
Pers#1	Experiences	6,17	< P(n) <	7,57		Expectations	8,07	< P(n) <	8,89
Pers#2	Experiences	5,95	< P(n) <	7,35		Expectations	8,74	< P(n) <	9,43
Pers#3	Experiences	5,69	< P(n) <	7,44		Expectations	8,95	< P(n) <	9,66
Pers#4	Experiences	6,11	< P(n) <	7,37		Expectations	8,60	< P(n) <	9,23
Pers#5	Experiences	6,03	< P(n) <	7,45		Expectations	7,96	< P(n) <	9,00
KPI#1	Experiences	6,84	< P(n) <	8,03		Expectations	8,67	< P(n) <	9,59
KPI#2	Experiences	8,57	< P(n) <	9,26		Expectations	9,32	< P(n) <	9,99
KPI#3	Experiences	6,51	< P(n) <	7,58		Expectations	8,96	< P(n) <	9,58
KPI#4	Experiences	6,82	< P(n) <	7,71		Expectations	8,51	< P(n) <	9,28
KPI#5	Experiences	6,70	< P(n) <	7,74		Expectations	8,59	< P(n) <	9,00
KPI#6	Experiences	6,22	< P(n) <	7,48		Expectations	8,47	< P(n) <	9,23
KPI#7	Experiences	7,88	< P(n) <	8,66		Expectations	8,16	< P(n) <	9,38
KPI#8	Experiences	7,29	< P(n) <	8,27		Expectations	7,37	< P(n) <	8,63
KPI#9	Experiences	7,40	< P(n) <	8,42		Expectations	6,47	< P(n) <	8,34

Table 1: 95 % confidential level for all the answers.

Experiences variation min value is 1,80 and max value is 1,87 while Expectation variation min value is 0,30 and max value is1,87 which are calculated according to Student's t-distribution.

All together the questionnaire consists of 29 questions categorized in four groups: Nine questions about the process, six questions about the product, five questions about the personnel, and nine questions about Key performance Indicators (KPI). The period of the question direction of the development and compared with competitor was considered in a time scale of two years; one year and two years ago. Time scale defining was based on the quite rapidly changing situations and the turbulent electronics manufacturing business.

Compared with competitors section, only our own personnel were asked, and therefore, it represents only an estimation of the customers' way of thinking. Due this limitation, the study sets more value on other parameters.

Table 2 shows the preliminary results analyzed by the methods introduced in this study.

	Avarage of the Expectations (1-10)	Standard deviation of the Expectations	Avarage of the Experiences (1-10)	Standard deviation of the Experiences	(2)Direction of development index
Proc#1	9,00	0,93	6,59	1,65	0,82
Proc#2	9,17	0,72	7,22	1,13	0,48
Proc#3	9,00	0,95	6,82	1,22	0,61
Proc#4	8,13	1,39	6,04	2,08	0,87
Proc#5	8,30	1,15	6,48	1,70	0,87
Proc#6	8,74	0,92	7,13	1,39	0,78
Proc#7	8,68	1,21	7,05	1,65	0,50
Proc#8	8,26	1,05	5,39	1,72	1,11
Proc#9	8,18	1,10	6,73	1,72	0,95
Prod#1	9,35	0,83	7,09	1,59	0,70
Prod#2	9,26	0,81	7,52	1,20	0,65
Prod#3	9,87	0,34	7,74	1,05	0,96
Prod#4	8,86	0,91	7,90	1,64	0,62
Prod#5	8,35	1,23	6,57	1,50	0,87
Prod#6	8,48	1,08	6,91	1,78	0,65
Pers#1	8,48	0,95	6,87	1,60	1,00
Pers#2	9,09	0,79	6,65	1,61	0,83
Pers#3	9,30	0,82	6,57	2,02	1,13
Pers#4	8,91	0,73	6,74	1,45	0,87
Pers#5	8,48	1,20	6,74	1,63	0,91
KPI#1	9,13	1,06	7,43	1,38	0,96
KPI#2	9,65	0,78	8,91	0,79	0,61
KPI#3	9,27	0,70	7,05	1,21	0,91
KPI#4	8,89	0,81	7,26	0,93	0,95
KPI#5	9,00	0,84	7,22	1,06	0,89
KPI#6	8,85	0,81	6,85	1,35	0,70
KPI#7	8,77	1,38	8,27	0,88	0,68
KPI#8	8,00	1,28	7,78	1,00	0,94
KPI#9	7,41	2,11	7,91	1,15	0,50

Table 2: Experience figures.

The following represents some findings about above preliminary analysis. Critical values of the experiences indicated in red color hit on the following groups: Process two, Product one and one in Personnel group. Respectively the experiences on a good level are indicated in yellow: two in Product and the rest four yellow signs are in the KPI group. The conclusion of this is that the experience of KPI is seen to be on a good level. The process group needs some improvements and the group Product needs to be considered with further analysis because it has both red and yellow sign values.

Some more consideration are done according to the results in Table 3, where the left part of the Table 3 represents an Average of the Experience and the right side represents the result of Critical Factor Index (CFI). The results are represented from sub-groups Management, Operations, R&D, Product Portfolio Management, Customer Support and group All.

	Average of the Experiences							Critial Factor Index CFI					
	Management	Operations	R / D	ProdPortFoMng	CusSupp	All		Management	Operations	R / D	ProdPortFoMng	CusSupp	All
Proc#1	6,50	6,00	7,20	6,67	6,00	6,59	Proc#1	1,41	1,72	0,53	0,89	#DIV/0!	1,67
Proc#2	6,50	7,75	7,60	7,67	7,33	7,22	Proc#2	0,52	3,92	#DIV/0!	0,00	1,02	1,54
Proc#3	6,25	6,75	6,60	7,33	7,33	6,82	Proc#3	1,59	1,25	2,13	1,65	1,45	1,74
Proc#4	5,00	6,00	6,00	6,33	6,67	6,04	Proc#4	8,76	1,62	1,50	2,23	0,64	3,38
Proc#5	5,25	6,00	7,00	7,67	6,33	6,48	Proc#5	2,63	2,32	1,19	0,70	0,84	2,28
Proc#6	7,50	7,00	7,00	7,00	7,33	7,13	Proc#6	1,92	1,07	0,67	0,43	0,00	1,60
Proc#7	7,00	7,00	7,20	8,00	7,00	7,05	Proc#7	3,49	2,02	1,49	9,92	1,02	3,95
Proc#8	4,00	5,00	5,00	6,50	6,50	5,39	Proc#8	1,19	1,40	1,49	0,00	1,21	1,53
Proc#9	6,25	6,50	6,60	7,67	7,50	6,73	Proc#9	3,96	1,55	3,44	0,69	0,00	2,11
Prod#1	6,75	7,50	7,00	6,67	6,67	7,09	Prod#1	#DIV/0!	1,75	1,03	2,37	0,56	1,66
Prod#2	8,00	8,25	7,20	7,67	7,00	7,52	Prod#2	1,49	2,82	0,56	1,85	0,00	1,37
Prod#3	7,50	7,50	7,80	8,00	7,67	7,74	Prod#3	0,00	0,00	0,21	0,38	0,43	0,32
Prod#4	8,75	8,00	8,40	8,50	8,00	7,90	Prod#4	2,10	1,11	1,01	3,17	0,00	2,49
Prod#5	5,25	6,75	6,60	7,33	7,00	6,57	Prod#5	3,47	1,15	1,64	2,28	0,57	2,16
Prod#6	6,25	7,00	7,00	8,00	6,67	6,91	Prod#6	7,49	2,52	1,76	5,32	0,76	3,01
Pers#1	7,00	7,75	6,60	5,33	7,33	6,87	Pers#1	2,68	3,05	0,40	0,98	0,68	1,54
Pers#2	6,25	6,50	6,60	6,33	7,67	6,65	Pers#2	2,13	1,01	0,83	0,70	1,05	1,37
Pers#3	6,00	6,50	6,40	7,00	7,00	6,57	Pers#3	1,07	0,00	0,86	2,41	0,00	1,24
Pers#4	6,75	7,75	6,40	5,67	7,00	6,74	Pers#4	2,70	0,45	0,70	0,52	0,61	1,13
Pers#5	5,75	7,50	7,00	7,33	7,00	6,74	Pers#5	3,31	1,87	0,83	2,43	1,98	2,15
KPI#1	7,50	7,00	7,60	6,67	7,33	7,43	KPI#1	0,00	0,71	1,08	3,54	0,25	1,42
KPI#2	9,00	9,25	8,80	8,67	9,33	8,91	KPI#2	0,00	0,00	1,10	0,24	1,07	0,97
KPI#3	6,50	7,00	7,40	7,33	7,00	7,05	KPI#3	0,77	0,00	0,00	1,98	0,43	0,83
KPI#4	7,25	7,25	7,00	7,33	9,00	7,26	KPI#4	1,65	1,49	0,25	0,22	#DIV/0!	0,77
KPI#5	6,50	7,25	7,00	7,33	9,00	7,22	KPI#5	0,94	1,73	0,00	0,54	#DIV/0!	0,95
KPI#6	6,25	7,00	6,60	7,67	7,00	6,85	KPI#6	4,01	2,31	1,60	0,70	#DIV/0!	1,47
KPI#7	8,25	9,00	8,20	7,67	8,50	8,27	KPI#7	0,94	2,57	0,22	3,48	1,32	1,94
KPI#8	8,75	7,25	7,60	6,50	8,00	7,78	KPI#8	1,49	2,43	0,53	1,82	#DIV/0!	1,67
KPI#9	9,25	8,25	7,40	8,33	7,50	7,91	KPI#9	#DIV/0!	3,83	1,38	3,77	#DIV/0!	6,89

Table 3: Average of experience and the Critical Factor Index.

The left part of the Table 3 represents the results of an Average of the Experience. Most of the red areas are on the process group with four red sign items and the personnel group with three red sign items. According to this finding, a conclusion can be made that Process and Personnel groups need corrective actions. The yellow sign of the groups Product and KPI indicates that respondents' experiments are on a good level.

The CFI values in the right side of the Table 3 are more disassembled. Dissection results of the lowest part of the Table 3 (KPI-values), it can be done at least to findings. First, the CFI results at the right and lower part of the Table 3 are quite opposite to the experiences at the left and lower part of the Table 3 where experiences results were in a good level meanwhile the CFI values include a lot of red values. Secondly, the upper part of CFI indicates also some red attributes, but also some yellow signs which represents a good result. The results have to be analyzed more analytically.

	STATUS		
Proc#1		NOK	
Proc#2	OK		
Proc#3	OK		
Proc#4			CONFLICTING
Proc#5		NOK	
Proc#6	OK		
Proc#7	OK		
Proc#8		NOK	
Proc#9	OK		
Prod#1	OK		
Prod#2	OK		
Prod#3		NOK	
Prod#4	OK		
Prod#5	OK		
Prod#6			CONFLICTING
Pers#1		NOK	
Pers#2			CONFLICTING
Pers#3			CONFLICTING
Pers#4		NOK	
Pers#5	OK		
KPI#1		NOK	
KPI#2			CONFLICTING
KPI#3		NOK	
KPI#4		NOK	
KPI#5			CONFLICTING
KPI#6	OK		
KPI#7	OK		
KPI#8			CONFLICTING
KPI#9	OK		

Table 4: Summary of Table 3.

According to Table 4, represented summary is based on the results of Table 3, all attributes marked with yellow represent mostly good, attributes marked with red indicate improvement areas, and a new sign marked “CONFLICTING” with blue color indicate that these attributes have both red and yellow colors and based on this, the final improvements areas have to be defined according to the results of Table 5.

	(2)Direction of development index	(3) Importance index	Critial factor index
Proc#1	0,82	0,90	1,67
Proc#2	0,48	0,92	1,54
Proc#3	0,6	0,90	1,74
Proc#4	0,87	0,81	3,38
Proc#5	0,87	0,83	2,28
Proc#6	0,78	0,87	1,60
Proc#7	0,50	0,87	3,95
Proc#8	1,11	0,83	1,53
Proc#9	0,95	0,82	2,11
Prod#1	0,70	0,93	1,66
Prod#2	0,65	0,93	1,37
Prod#3	0,96	0,99	0,32
Prod#4	0,62	0,89	2,49
Prod#5	0,87	0,83	2,16
Prod#6	0,65	0,85	3,01
Pers#1	1,00	0,85	1,54
Pers#2	0,83	0,91	1,37
Pers#3	1,13	0,93	1,24
Pers#4	0,87	0,89	1,13
Pers#5	0,91	0,85	2,15
KPI#1	0,96	0,91	1,42
KPI#2	0,61	0,97	0,97
KPI#3	0,91	0,93	0,83
KPI#4	0,95	0,89	0,77
KPI#5	0,89	0,90	0,95
KPI#6	0,70	0,89	1,47
KPI#7	0,68	0,88	1,94
KPI#8	0,94	0,80	1,67
KPI#9	0,50	0,74	6,89

Table 5: Direction of development index, Importance Index and Critical Factors Index (CFI).

The direction of the experience development index has only two values where the index indicates the worse development direction (Process #8 and Personnel #3), all other indicate to remain on the same level or to improve. The Importance Index indicates that Prod #3 with value 0,99 and KPI#2 with value 0,97 has more importance than other.

Finally the most potential development areas can be nominated according to the indication by CFI: Product group on one, item Prod#3 and KPI group four items: KPI#2, KPI#3, KPI#4. KPI#5.

The nominated most critical items are represented also on Figure 4 with red color and the respectively items in good situation are with yellow –color.

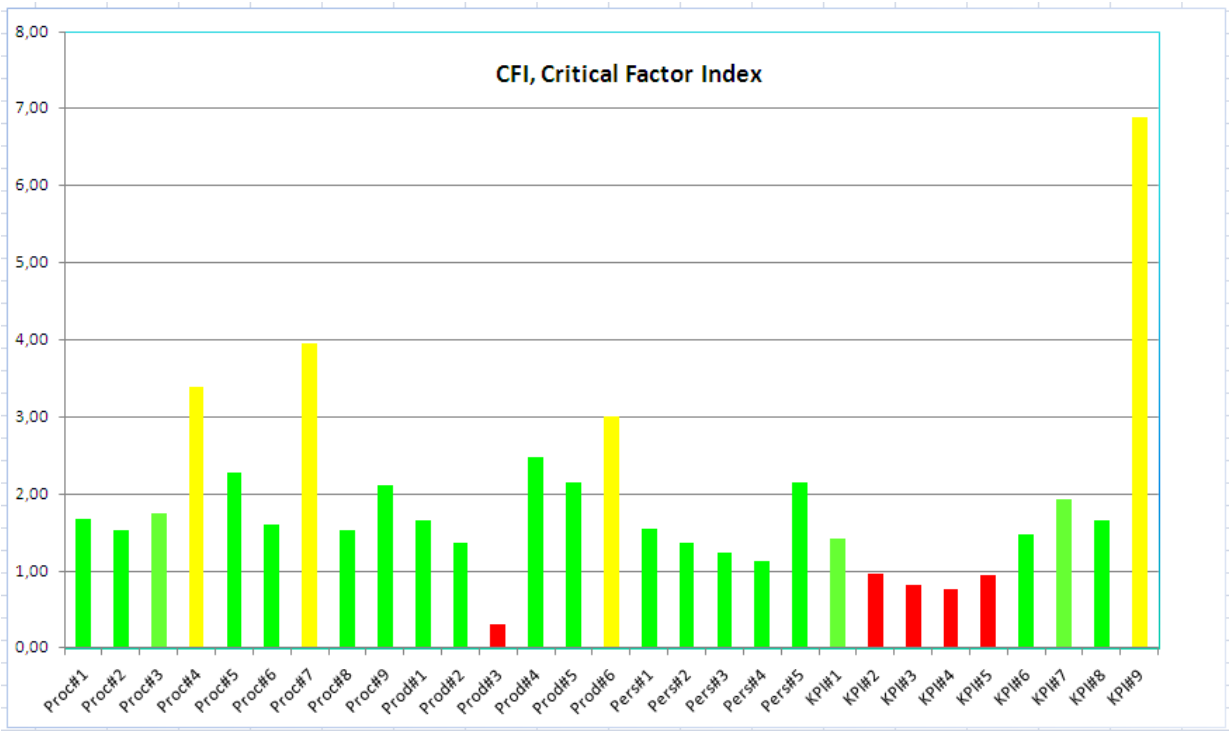

Figure 4: Results of Critical Factors Index.

UTILIZATION AND EVALUATION OF THE RESULTS

The evaluation of the weak market test question is how the method describes the development areas as expected. As mentioned, the study has some limitation on how much value can be set on the customers' way of thinking. Due to this limitation, more value has been set on the average of the experience, the direction of the development index and finally, in the CFI index.

The empirical material has partly low scope, especially with Sales & Marketing (two of eight responders) and Other Management (two of eight responders). Due to this limitation, only the results from Management, Operations, R&D, Product Portfolio Management and Customer Support departments are used in the analysis.

The Sense and Respond method has been basically used as in earlier studies. This study contains more comparison between the questionnaire groups and also between the departments. Also the answers received from the questionnaire have been tested by Student's t-distribution and 95 % confidential level has been calculated.

The differences between the different groups of organization on average of the experience and Critical Factor Index were large. One reason for the gap might be that different functions of the company are working independently. Actually the results from the business process re-engineering workshops performed in the company support thinking of this kind of way (the workshops are not presented in this study).

The used Sense and Response research method identified the most important attributes which indicated low CFI values. Concerning the CFI and average of experience as most important result of the study, the study indicates the most critical development areas as written above based on information of Table 5 and Figure 4.

The major managerial implication of the study has been to specify the guidelines of the process redesign activities in the case company. Also the implemented study provided important information about essential themes, such as quality and customer closeness.

CONCLUSIONS

The focus of the questionnaire was very large and it gave a general view of the organization's status regarding its capability in general. The case organization had recognized a need for to investigate quality improvement actions. A fundamental way to perform the actions was an idea to improve performance by doing process redesign activities. The theoretical review at the beginning of the study gave fundamental information about Quality, Quality Tools, Total Quality Management, Business Process Redesign, Process Organization and Customer Closeness. Together, the empirical part of the study is based on the research on the Sense and Respond method.The theoretical review on the necessary areas gives a source of information for the case organization to go further with the business process redesign activities. The practical importance of the study delivers important information for Process Redesign in order to streamline the processes. Secondly the company has also set a target to increase registration and follow up of the COPQ expenses.

A further study is to investigate and perform Business Process Redesign activities based on these study and separately performed process workshops. After the Business Process Redesign activities have been taken into effect, it is recommendable to perform a Sense and Respond follow-up study. During the follow-up study it would be possible to take the improvements presented in this study into account.

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AGENT-BASED MODELING OF THE SOFTWARE INDUSTRY STRUCTURE IN JAPAN: PRELIMINARY CONSIDERATION OF INFLUENCE OF OFFSHORING IN CHINA

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ABSTRACT

This study aims at the preliminary assessment of the future software industry structure in Japan from the viewpoint of the influence of offshoring in China based on surveys on software engineering capabilities of Japanese IT vendors with the Japanese Ministry of Economy, Trade and Industry. Through the agent-based simulation model mainly focusing on customer's price preference and communication quality with customers, Japanese vendors can possibly lose their share of the market if Japanese customers prefer the lower prices offered by offshore vendors. The results suggest that Japanese vendors should improve their communication skill to realize the customer's requirements for the quality of enterprise software while avoiding the cost competition with the Chinese vendors and considering the customer's price preference. Otherwise, some Japanese vendors within the current multi-layered software industry culture will not survive in the drastically changing Japanese market.

Keywords: software industry, agent-based modeling, innovation

INTRODUCTION

The information service industry in Japan is a 10.5 trillion yen market, which includes 7.6 trillion yen in software development and programming. In 2009, orders for software totaled 6.4 trillion yen and accounted for 60.3% of the entire information service industry, while the market for software products was only 1.2 trillion yen (Ministry of Economy, Trade and Industry, Japan, 2010).

However, software vendors in Japan are facing drastic changes in their business environment due to technology innovations and new entrants from emerging countries, such as China, India, and others, despite domestic Japanese software industry has been showing low growth. Also, the issues in the IT industry in Japan, such as the multilayer subcontractors and the business model depending on custom-made applications for domestic market orientation, have been pointed out over times (Cusumano, M., 2004; Kadono, Y., 2007). The multilayer subcontractors industry structure implies the posibility of the growth accelleration of software development offshoring in China and other countries.

In fact, the offshore software development market has experienced high growth: 63.6 billion yen in 2005, 103.5 billion yen in 2007 and an expected 199.5 billion yen in 2010. In 2007, 36.8% of Japanese software development firms developed software offshore to reduce costs and to complement Japan's 80% deficit of domestic human resources. In 2005, the offshore development in China was 53 billion yen, accounting for 83.5% of the entire offshore

development for Japan (Kondo, 2009; Ministry of General Affairs, Japan, 2007).

Compared to Japan's 10.5 trillion yen market, the information service industry in China is still lower at 9.3 trillion yen, but has been growing by more than 20% annually since 2002. The export of software from China was 3.6 billion dollars (approximately 396 billion yen) in 2005 and has been growing by over 30% annually since 2002 (Kondo, 2009; Ministry of General Affairs, Japan, 2007). Therefore, new entrants from China entering into the Japan market are becoming a threat to Japanese domestic software vendors (Porter, 1980).

OBJECTIVES AND METHOD

The focus of this study is an assessment of the market shares in Japan of Japanese and Chinese software vendors and the conditions for sustaining the competitive advantage of Japanese vendors in the similar situations to the current software industry in Japan based on a survey on software engineering excellence (SEE) in 2005, 2006 and 2007 with the Japanese Ministry of Economy, Trade and Industry. In the survey, we collected data of software engineering and competitive environment from 233 IT vendors in Japan totally (Kadono et al. 2006). The assessment is conducted through an agent-based simulation that is an extension of the Sugarscape model (Epstein and Axtell, 1996; Kadono et al., 2002; Yamakage, 2007) under the condition that the price preference of Japanese software customers is changing.
In this paper, we assume Japanese and Chinese vendors to be agents and set parameters such as communication levels, service levels, switching cost and price preferences. Also, we assume that Japanese vendor can outsource projects only to another Japanese vendor under certain conditions.

Then, we model the following two scenarios considering the above situations:
- customers prefer the communication level and the price level simultaneously, and
- customers prefer the price level over the communication level, which directly influences the quality of the software.

SIMULATION MODEL

Agents and parameters

In this paper we assume the agents are Japanese vendors, Chinese vendors, and customers. The following parameters are set based on the current situations of the Japanese enterprise software service industry (Kadono, Tsubaki, Tsuruho, 2006; Kadono, 2007; Kadono, Tsubaki, Tsuruho, 2009; Kadono, Imanishi, 2011).

- Japanese and Chinese vendors
  - Number of vendors: Japanese vendors are in the majority in the current Japanese market.
  - Improvement of communication level: Chinese vendors have increasingly improved their communication levels to meet the requirements of Japanese customers.
  - Improvement of price level: Japanese and Chinese vendors reduce their prices to

meet the requirements of Japanese customers.
  - Switching cost: Chinese vendors need to pay more initial cost for new customers.
  - Outsourcing scope of Japanese vendors: Japanese vendor can outsource their projects only to another Japanese vendor, although Chinese vendors cannot outsource their projects to the other vendors.

- Customers
  - Number of customers: sufficient software customers exist in the current Japanese market.
  - Desirable communication level: Japanese customers take into account the communication level of Japanese vendors.
  - Preference of low price: Japanese customers also take into account the price.

Algorithm

In this agent-based simulation, the agents of Japanese and Chinese vendors and customers are distributed randomly on a 50x50 matrix, as shown in Figure 1. The mobile direction of each vendor agent is randomly set. Each vendor agent moves one cell per time step based on the following algorithm until either the Japanese or the Chinese vendors monopolize the market or until the time reaches the certain limit steps.

Step 1: A vendor agent moves by one cell randomly.
Step 2: The vendor successfully makes a contract if encountering a customer whose requirements of communication level and price meet the vendor's offering.
Step 3: If the Japanese vendor make a contract, it can outsource the project to another Japanese vendor within accessible distance from the Japanese prime contractor.
Step 4: The vendor improves its communication level depending on the parameter of improvement of the communication level. Also, the vendor reduces the price depending on the parameter of improvement of the price level if the vendor cannot get the customer to agree to a contract.
Step 5: The market share is updated depending on the contracts completed by the Japanese and Chinese vendors.

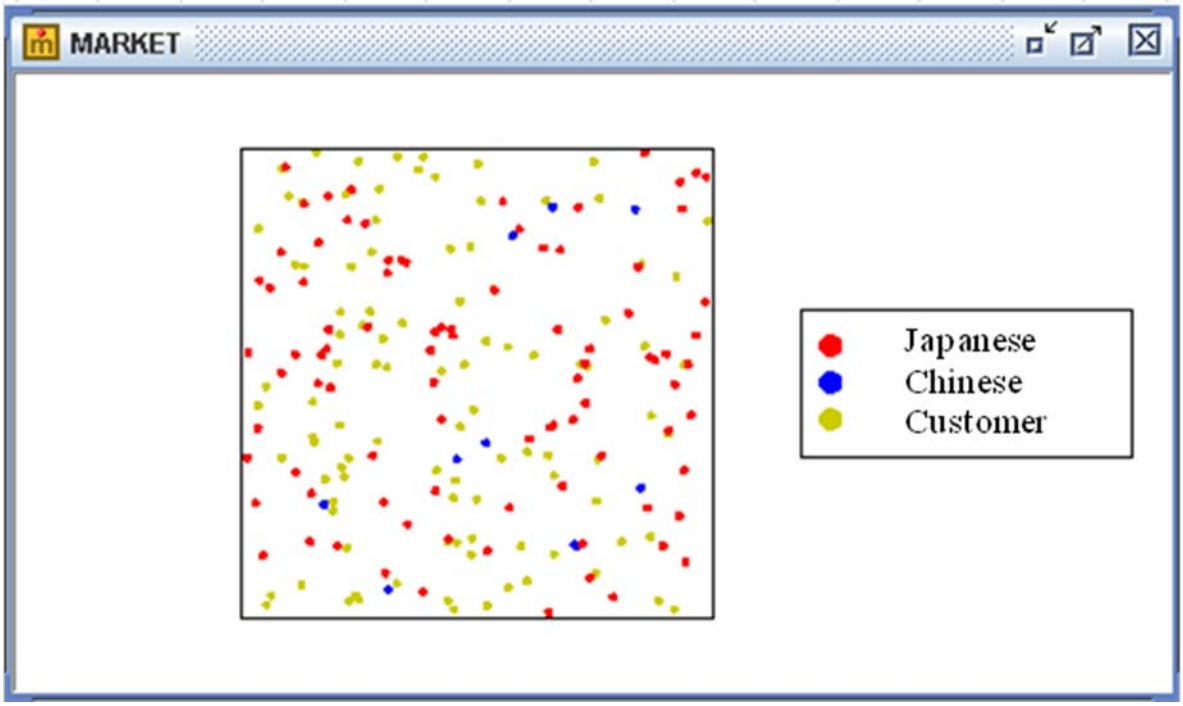

Figure 1: Market in the agent-based modeling
Japanese vendors (read circles), Chinese vendors (blue circles), and customers (yellow circles) on the market (50x50 matrix).

Simulation conditions and parameters

We assume the following two conditions regarding the communication levels and the prices of software development:

1. Customers seek the communication level and the price simultaneously, i.e.,
   A customer contracts with a vendor if the communication level of the vendor >= the communication level the customer requires + the switching cost, and if the price level of the vendor >= the price level the customer requires + the switching cost.
2. Customers prefer the price level to the communication level, i.e.,
   A customer contracts with a vendor if the price level of the vendor >= the price level the customer requires + (the communication level the customer requires – the communication level of the vendor) * (2 – the price preference of the customer) + the switching cost. The price preference of the customer is defined as more than 0.1 and less than 0.9.

In terms of the simulation parameters of the Japanese and Chinese vendors, based on the current industry situations, we assume the number of agents, communication level, price level, switching cost, price reduction and communication level improvement are as shown in Table 1. Also, we assume the number of customers is 100 and the preference of price is 0.8. And, the outsourcing scope of Japanese vendors is 3, while the outsourcing scope of Chinese vendors is not applicable (NA).

Table 1: Basic parameters.

	Japanese vendor	Chinese vendor
Number of vendors	90	10
Communication level	10	7
Price level	7	10
Switching cost	0.1	0.2
Price reduction (%)	0.02	0.04
Communication level improvement (%)	0.005	0.005
Number of potential customers	100	100
Customer's preference of price	0.8	0.8
Outsourcing scope	3	NA

RESULTS

First, we investigated the following two cases using basic parameters in Table1.

Case 1: the simulation with condition 1 (customers seek the communication level and the price simultaneously). The results are shown in Figure 2.

Case 2: the simulation with conditions 1 and 2 (customers prefer the price level over the communication level). The results are shown in Figure 3.

In Figures 2 and 3, the horizontal axis indicates one-tenth of the number of simulation steps and the vertical axis indicates the share of the market by the Japanese and the Chinese software vendors.

In Case 1, the Japanese vendors keep a more competitive situation than do the Chinese vendors until the end.

In Case 2, the share of the Chinese vendors remains 7% until the 1,650th step, begins to increase at the 1,650th step and the 2,100th step, then overcomes the Japanese vendors, and finally dominates the market. This means that Japanese vendors possibly lose their market share if the Japanese customers increasingly prefer the lower price.

These results suggest that Japanese vendors should improve their communication skill to realize the customer’s requirements while avoiding the cost competition with the Chinese vendors considering customer’s price preference. Otherwise, some Japanese vendors will not survive in the Japanese market.

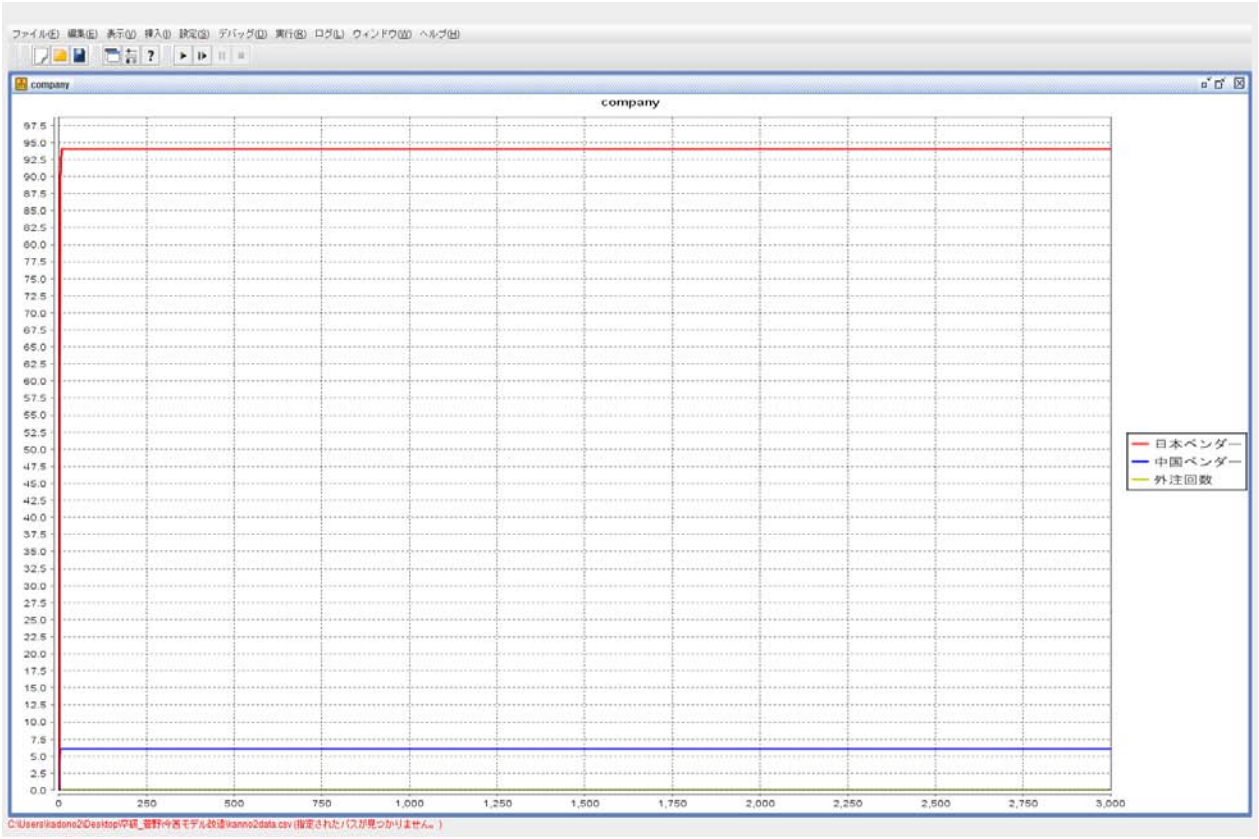

Figure 2: Result of Case 1 with parameters in Table 1.
Vertical axis: share of market of Japanese vendors (red line) and Chinese vendors (blue line).
Horizontal axis: simulation steps*1/10.

Figure 3: Result of Case 2 with parameters in Table 1.

Second, we performed the preliminary analyses in Case 2 with different parameters from those in Table 1, such as the number of Chinese vendors, the Japanese price level, scope of outsourcing from Japanese vendors to Japanese vendors.

For example, even if the number of Chinese vendors is 2 and the number of Japanese vendors is 100, Chinese vendors result in overcoming the Japanese vendors if Japanese price level is 5 (Figure 4). On the other hand, if Japanese vendors improve their price level up to 8, Japanese market reject one Chinese vendor and Japanese vendors dominate the market (APPENDIX: Figure 5).

Figure 4: Result of Case 2 with parameters: Chinese vendor = 2 and Japanese price level = 5.

Another case is shown in Figure 6 (APPENDIX), where both of Japanese and Chinese price levels are 8 and the Japanese outsourcing scope is 9. In the case we can observe that Chinese vendors are revitalized after decreasing its share of market until around the 100th step.

Furthermore, we can observe several phenomena with various combinations of vendor's parameters in Table 1, such as number of vendors, communication level, improvement of communication level, price level, improvement of price level, switching cost, outsourcing scope not only for Japanese vendors but also for Chinese vendors. Regarding the parameters of customers, we can further consider the number of customers, desirable communication level of customers, preference of price, and other parameters.

CONCLUSIONS AND DISCUSSION

This study constructed a simplified agent-based simulation model to preliminary estimate the tradeoff between the communication skill and the price of Japanese and Chinese

software vendors. Based on the results of the agent-based simulation, Japanese vendors could lose their share of the market if the Japanese customers increasingly prefer the lower price. Consequently, to survive intense global competition, Japanese vendors must enhance their communication skill to improve their software outcome and simultaneously enhance the cost competition with Chinese vendors.

In this paper, our focus was assessing the influence of future offshore development on the Japanese enterprise software service industry, particularly in relation to Chinese software vendors. However, the software vendors in Japan are facing drastic changes in their business environment due to technology innovations and new participants from emerging countries, including China, into the low-growth Japanese domestic software industry. In order for the software industry in Japan to meet these challenges, an important step is also to evaluate the significance of the software engineering capabilities for achieving medium- and long-term success.

Therefore, we designed surveys on software engineering excellence (Barney, 2007; Bollen, 1989; Carnegie Mellon University; Fujimoto, 2003; Matsumoto, 2005; Ministry of Economy, Trade and Industry, Japan, 2010) and administered them in 2005, 2006 and 2007 with the Ministry of Economy, Trade and Industry, Japan (METI) (Kadono et al. 2006). By surveying the previous papers on the types of Japanese software vendors (Kadono et al. 2009), we found that the software maker-turned-vendors tend to significantly expand business with well-resourced R&D, while the user-turned-vendors seem to depend heavily on the demand of the parent companies. Therefore, some of user-turned-vendors are thought to gain inimitable capabilities. In contrast, many of the independent vendors serve as non-principal contractors that supply people without specific strengths as temporary staffing in a multi-layer industry structure. However, some of the independent vendors with inimitable assets are thought to be the role models of software vendors in Japan. Based on these results, for future study, we suggest considering the relationship between the types of Japanese software vendors and the key factors to the success of offshore software development.

Also, in order to model the current and future structures of the software industry in Japan, we developed another agent-based simulation model that was an extension of the Sugarscape model (Epstein and Axtell, 1996; Kadono et al., 2002; Yamakage, 2007). The model consisted of software vendors with variations in their scale, innovation adoption and outsourcing ratio. In the model, we assumed that the market would follow the innovation cycle of technology for mainframe computers, client servers, Web applications, cloud computing services, and so on, and that the larger software vendors would tend to invest more in the technology innovation and outsource more jobs to the smaller software vendors in a multi-layer industry structure (Kadono, Terano, Ohkuma, 2010).

For the investigation, we set the following three scenarios. In each scenario, we continue to pursue the conditions and parameters of availability through the agent-based simulation model.

- Survival by size and skill: the big software vendors grow increasingly due to their resourceful staffs and skills based on the scale merit and the scope merit, whereas the small/medium-sized software vendors do not survive without catching up with the rapid

technology innovation. As a result, the software industry structure in Japan will consist of a smaller number of players with clear characterizations of their scale or special skills.

- Reciprocal relationships: all types of the current players survive by outsourcing the jobs from the big (medium-sized) software vendors to the medium-sized (small) software vendors in the current multi-layer software industry structure. Particularly, the small software vendors will not survive without outsourcing from the big (medium-sized) vendors.
- Reverse phenomena: some medium-sized technology-oriented vendors outpace big software vendors who tend not to invest as much in technology innovation.

Based on the above scenarios, we suggested that future studies be conducted on the following: interactive behaviors among software vendors, e.g., a project-based alliance and a merger and acquisition (M&A); influences of offshore developments and new participants on the Japanese software industry.

Finally, to expand this paper, we would integrate findings in the above papers regarding the types of Japanese software vendors and the Japanese software industry structure into this paper, and assess the future Japanese software industry structure in relation to China, India, the U.S. and the rest of the world.

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APENDIX

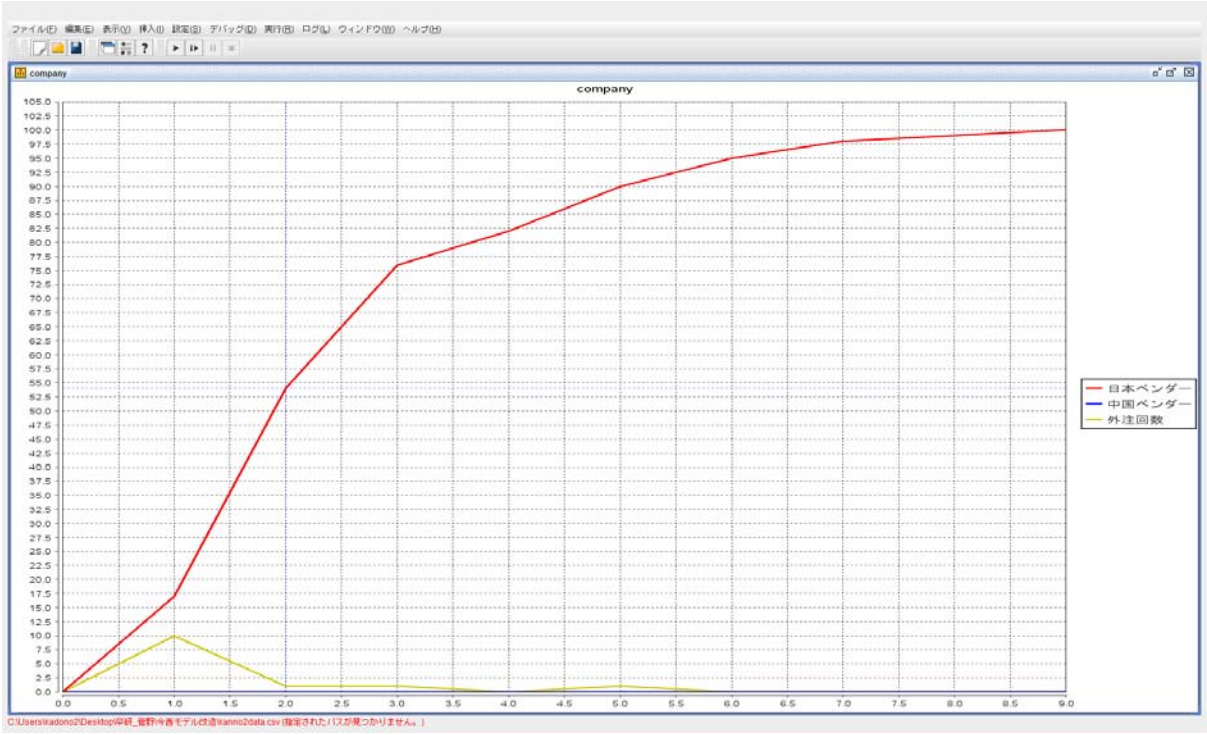

Figure 5: Result of Case 2 with parameters: Chinese vendor = 1 and Japanese price level = 8.

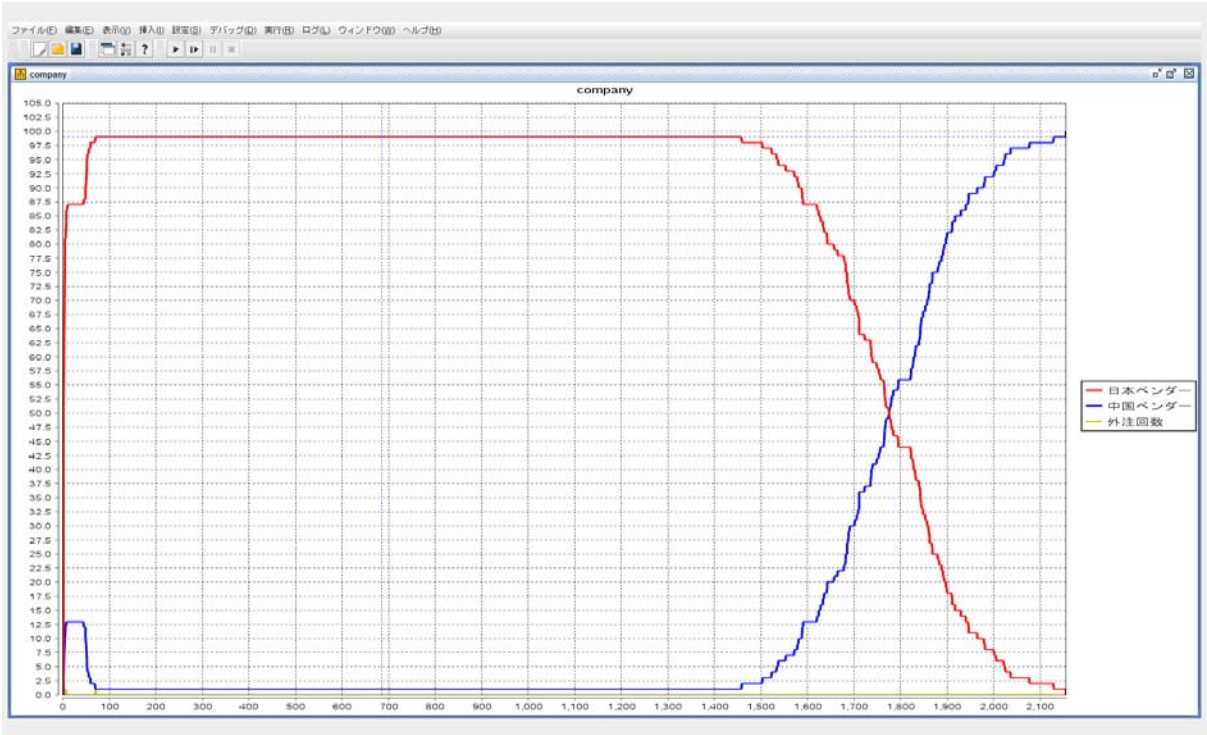

Figure 6: Result of Case 2 with parameters: Japanese and Chinese price level = 8. Japanese outsourcing scope = 9.

AN EMPIRICAL STUDY OF THE RELATIONSHIP BETWEEN INTELLECTUAL CAPITAL AND THE PERFORMANCE OF A MANUFACTURING FIRM

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ABSTRACT

Introduction—*The competitiveness of a country's manufacturing sector is critical to its long-term economic prosperity and growth. The manufacturing sector creates a sustainable economic in country. A strong manufacturing sector also encourages a country's intellectual capital and innovativeness, underwriting research and development, pushing the technological envelope, and driving the growth in demand for highly skilled workers and scientists.*

Many manufacturing firms in Thailand's stock market do not have good research and development; there are 24 big market capitals manufacturing firms in Thailand SET100, and only 11 of them have expenditure in research and development. As we know, one of the outputs of research and development is intangible assets.

In current economic knowledge, an intangible asset is considered the key factor to increase manufacturing competitiveness performance. Many manufacturing firms in Thailand support world-class manufacturing systems located in Thailand—such as Toyota, Honda, Seagate, and more. Therefore, Thailand manufacturing firms should understand principle of intangible assets (Intellectual capital) for measurement and how to manage it.

Purpose—*The purposes of this research are as follows–*
1. Review the definition and classification of intellectual capital.
2. Apply intellectual capital measurement tools in manufacturing firms.
3. Study the interactive effect between intellectual capital and the manufacturing firm's performance.
4. Investigate empirically the effects of human capital, structural capital, and innovation capital on the manufacturing firms' performance.

Design/methodology/approach—*Data was used from Thailand's list of manufacturing companies and Value Added Intellectual Coefficient (VAICe) as the efficiency measure of human capital, structural capital, innovation capital, capital employed, and intellectual capital. The author applied correlation to examine the relationship between intellectual capital and manufacturing firms' performance. The author constructs multiregression models to examine the relationship between sub capital of intellectual capital (human capital, structural capital, innovation capital, and capital employed) and manufacturing firms' performance (return on equity, return on assets, growth in revenues, and employee productivity).*

Findings—*Intellectual capital positively and significantly affects a manufacturing firm's performance. The study proves that there are interactive effects between the sub capital of intellectual capital and the manufacturing firm's performance, as demonstrated below.*
Sub capital effect on manufacturing firm's performance
1. *Innovation capital is positively associated with growth revenue.*
2. *Human capital is positively associated with return on asset and employee productivity.*
3. *Capital employed is positively associated with return on equity and return on assets.*

Key words: Intellectual capital, Intangible assets, Human capital, Innovation capital, Structural capital, Manufacturing firm, Firms' performance.

INTRODUCTION

A manufacturing sector is very important for developing country because the manufacturing sector creates a sustainable economic ecosystem, increase foreign investment and enhances a country's balance payments. The strong manufacturing sector also encourages a country's intellectual capital and innovativeness. Customer requirement and technology are pushing more research and development in product and process. And high global competitiveness in knowledge economy is also driving a manufacturing firm need to develop more highly knowledge worker, engineer and scientist to support their research and development.

One of the research and development output is intangible assets such as intellectual property, patent etc. And this output is not generated only from tangible asset. There are also generated from intangible assets such as worker's skill, experience, firm's policy, IT system, firm's strategy and etc.

A performance of manufacturing firm also generate from tangible and intangible assets of the firm. The issue is not happened if the intangible asset is easily to measure. So the main problem is how to measure intangible assets in a manufacturing firm. And there are any relationship between intangible asset and a firm's performance.

Currently we call intellectual capital (IC) instead of intangible asset. Understand in IC is the first thing that we must do but until now a definition of IC is not defined. Not only the definition is not valid, the relationship between a firm's performances and IC is not valid also. Why we want to know the relationship between IC and a firm's performance? Because if IC is increase but your firm performance is decrease it's mean you may go to the wrong measurement way. IC increase and also a firm's performance increase, it make sense to keep monitor and improve a firm's IC.

This research paper aims to define the classification of the Intellectual capital, how to apply the measurement tool and proved a relationship between IC and manufacturing firms' performance. The main part of this article are consist of
1. Definition and classification of Intellectual capital.
2. VAIC^{TM} definition and how to calculate each sub-capital of Intellectual capital.

3. Research model and hypotheses.
4. Regression analysis and result.

DEFINITION AND CLASSIFICATION OF INTELLECTUAL CAPITAL (IC)

Definition of Intellectual capital

Definition of Intellectual capital is not a conclusion and the main message that we find from many researchers are "Intellectual capital is the intangible value generated from human (Knowledge, motivation etc.) and resources (Equipment, i.e. Computer, IT etc.), and contribute to the firm's value added". Stewart (1997) define Intellectual capital as the sum of everything everybody in the company that gives it a competitive edge in the market place. Edvinsson and Sullivan (1996) define Intellectual capital as knowledge that can be converted into value. Brooking (1997) define Intellectual capital as the term given to combined intangible assets which enable the company to function.

Edvinsson and Malone (1997) define Intellectual capital as those that have no physical existence but are still of value to the company.

Brennan and Connell (2000) define Intellectual capital as knowledge-based equity of a company. Harrison and Sullivan (2000) define Intellectual capital as knowledge that can be converted into profit. A broad definition of intellectual capital states that it is the difference between the company's market value and its book value. Knowledge based resources that contribute to the sustained competitive advantage of the firm from intellectual capital Pablos (2003). Andriesssen and Stem (2004) define Intellectual capital as all intangible resources that are available to an organization, that gives a relative advantage, and which in combinations are able to produce future benefits. Yound (2004) define Intellectual capital as the sum of all knowledge that an organization is able to leverage in the process of conducting business to gain competitive advantage. Roose (2005) define Intellectual capital as all non-monetary and non-physical resources that are fully or partly controlled by the organization and that contribute to the organization's value creation.

Classification of Intellectual capital

The capital in Intellectual capital is very important. Classification of Intellectual capital is provided and it helps the researcher to understand the definition of Intellectual capital. Practitioners also know which capital should be more focused on to increase the intellectual capital in company. And they know well where the strategy begins.

Edvinsson and Malone (1997): Intellectual capital consists of structural capital and human capital.

Definition of each capital

Human Capital is defined as the collective capabilities of employees to solve customer problems. This capital includes the collective experience, skills, and general know-how of all of the company's employees.

Structural capital consists of customer capital and organizational capital. Organizational capital consists of innovation capital and process capital.

Definition of each capital

Structural capital includes customer and organizational capital that relates to the external and the internal focus of structural capital.

Customer capital is defined as the combined value of the relationships with customers, suppliers, industry associations and markets.

Organizational capital includes the organization philosophy and systems for leveraging the organization’s capability.

Innovation capital is that which creates success in the future and includes intellectual assets and intellectual property.

Process capital includes the techniques, procedures, and programs that implement and enhance the delivery of goods and services.

Sveiby (1997): Intangible assets or IC consist of External structure, Internal structure and Individual competence.

The definition of each component

Internal structure consists of a wide range of patents, concepts, models, and computer and administrative systems.

External structure consists of relationships with customers and suppliers, brand names, trademarks and reputation, or "image".

Individual competence is people's capacity to act in various situations. It includes skill, education, experience, values and social skills.

Brooking (1997): Intellectual capital consist of Market assets, Human-centered assets, Intellectual property assets and Infrastructure assets.

The definition of each asset

Market assets are the potential an organization has due to market-related intangible. Examples include various brands, customers and their loyalty, repeat business, backlog, distribution channels, various contacts and agreements such as licensing, franchise.

Human-centered assets comprise the collective expertise, creative and problem solving capability, leadership, entrepreneurial and managerial skills embodies by the employees of the organization.

Intellectual property assets include know-how, trade secrets, copy-right, patent and various design rights. They also include trade and service marks.

Infrastructure assets are those technologies, methodologies and processes which enable the organization to function. Examples include corporate culture, methodologies for assessing risk, methods of managing a sales force, financial structure, data base and communication systems.

Bontis (1999): Intellectual capital consists of Human capital, Structural capital and Relational capital.

The definition of each capital,

Human capital is defined as the combined knowledge, skill, innovativeness, and ability of the company's individual employees to meet the task at hand. It also includes the company's values, culture, and philosophy.

Structural capital deals with the mechanisms and structures of the organization that can help support employees in their quest for optimum intellectual performance and therefore overall business performance.

Relational capital is knowledge of market channels, customer and supplier relationships, as well as a sound understanding of government or industry association impacts.

Chen, Zhu and Xie (2004): Intellectual capital consists of Human capital, Structural capital, Innovation capital and Customer capital.

The definition of each capital

Human capital is defined as employees' knowledge, skill, capability, and attitudes in relation to fostering performances which customers are willing to pay for and which the company's profit comes from.

Structural capital deals with the mechanism and structure of an enterprise that can help support employees in their quest for optimum intellectual performance, and the overall business performance achievement.

Innovation capital is the competence of organizing and implementing R&D, unremittingly bringing forth the new technology and the new product to meet the demands of customers.

Customer capital is the value embedded in the marketing channels and relationships that an enterprise develops by conducting business.

In the new economic era, innovation is becoming a key factor for a company to keep its long-term competitive excellence. Economic growth in developed countries has been driven by innovation rather than by investment. Then Chen, Zhu and Xie (2004) agree to separate Innovation capital from Structural capital.

In this research, Intellectual capital consists of Human capital, Structural capital and Innovation capital. The model of research and hypothesis are provided in part_3.

VAIC^{TM} DEFINITION AND CALCULATION METHOD OF EACH SUB-CAPITAL OF INTELLECTUAL CAPITAL

Value Added Intellectual Coefficient (VAICe) is widely applied in the Intellectual capital research and it was devised by the Austrian Intellectual Capital Research Center (AICRS) under Pulic (2000b). VAIC^{TM} uses the data from financial statements and using value added to measure performance. It measures how much and how efficiently intellectual capital and capital employed create value based on the relationship to the three major components. They are capital employed (CE), human capital (HU) and structural capital (ST).

In this research, Innovation capital is one of indicator in VAIC^{TM} and the R&D expenditure is used for calculating the VA efficiency of Innovation capital (Nazari and Herremans, 2007).

VAIC^{TM} Calculation method

Calculation formula: VAIC = VAHU + STVA + VACA + InCE

Component calculation

VACA is indicator of VA efficiency of capital employed = VA ÷ CE
VAHU is indicator of VA efficiency of human capital = VA ÷ HU
STVA is indicator of VA efficiency of structural capital = SC ÷ VA
InCE is indicator of VA efficiency of innovation capital = R&D ÷ VA

Where

VA = Net sales revenue - Cost of good sold - Depreciation (Riahi-Belkaoui (2003))

CE = Physical capital + Financial assets
= Total assets - Intangible assets (Pulic (2000a, b) and Firer and Williams (2003))

HU = Total expenditure on employees (Pulic (2000a, b) and Firer and Williams (2003))

SC = VA - HU (Pulic (2000a, b) and Firer and Williams (2003))

R&D = Total R&D expenditure (Bosworth and Rogers, 2001)

Many researchers had applied VAIC method to measure IC in firm and studied how IC related to a firm's performance. Chen, Cheng and Hwang (2005) conclude that IC has a positive impact on market to book value and financial performance of Taiwan listed company. And the R&D expenditure may capture additional information on Structural capital and has a positive effect on firm value and profitability also. Chan (2009) conclude no significant related between IC and a firm performance of Hong Kong listed company. Only a moderate positive association has been found between VAICe and profitability.

RESEARCH MODEL AND HYPOTHESES.

Research model

The purpose of the model is to define,
1. The relationship between Intellectual capital and manufacturing firm performance.
2. The effect of each sub-capital to the manufacturing performance.

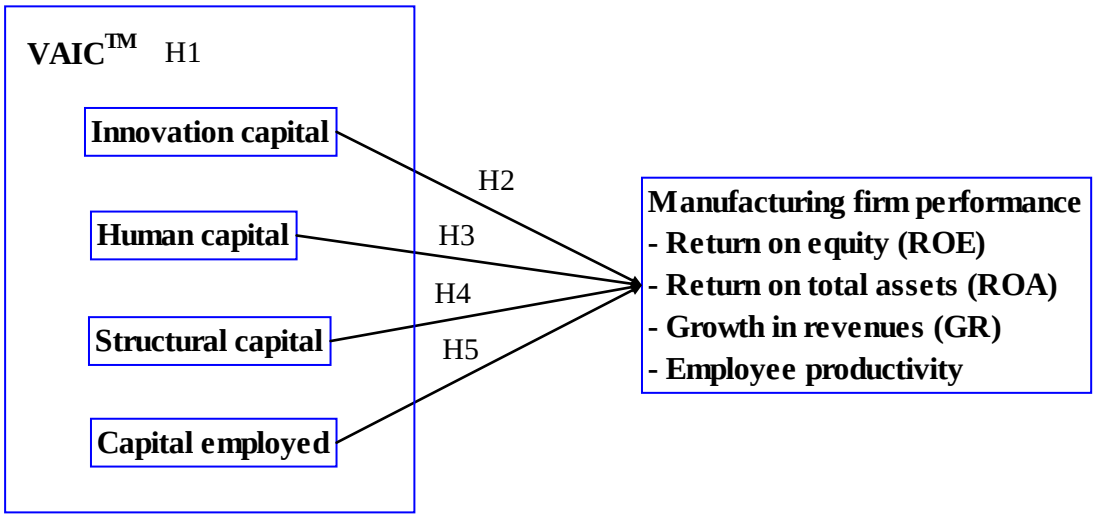

Figure I. Framework of research hypotheses

Manufacturing performance definition and hypotheses
Company performance: Considered in term of value added.
Financial performance. The four financial performance variables are defined as follows:

. Return on equity (ROE) = pre - tax income ÷ average stockholders' equity.

ROE represents returns to shareholders of common stocks, and is generally considered an important financial indicator for investors.

. Return on total assets (ROA) = pre - tax income ÷ average total assets.

ROA reflects firms' efficiency in utilizing total assets, holding constant firms' financing policy.

. Growth in revenues (GR) = (current year's revenues ÷ last year's revenues) - 1) × 100%.

GR measures the changes in firms' revenues. Increases in revenues usually signal firms' opportunities for growth.

. Employee productivity (EP) = pre - tax income ÷ number of employees.

EP is a measure for the net value added per employee, reflecting employees' productivity.

Hypotheses on Research model

Intellectual capital effect to manufacturing performance
H1a. VAIC^{TM} positive associated with ROE
H1b. VAIC^{TM} positive associated with ROA
H1c. VAIC^{TM} positive associated with GR
H1d. VAIC^{TM} positive associated with EP

Sub-capital effect to manufacturing performance
H2a. Innovation capital positive associated with ROE
H2b. Innovation capital positive associated with ROA
H2c. Innovation capital positive associated with GR
H2d. Innovation capital positive associated with EP
H3a. Human capital positive associated with ROE
H3b. Human capital positive associated with ROA
H3c. Human capital positive associated with GR
H3d. Human capital positive associated with EP
H4a. Structural capital positive associated with ROE
H4b. Structural capital positive associated with ROA
H4c. Structural capital positive associated with GR
H4d. Structural capital positive associated with EP

H5a. Capital employed positive associated with ROE
H5b. Capital employed positive associated with ROA
H5c. Capital employed positive associated with GR
H5d. Capital employed positive associated with EP

Sample selection and method

Manufacturing companies were selected from Thailand listed companies in SET100 (Big market capital).There are 24 manufacturing companies from a total of 100 companies. Others are service and finance companies.11 companies from 24 companies which can be used because they have R&D expenditure shown in the annual report. These companies consist of 3 automobile part manufacturing firms, 2 electronic component manufacturing firms, 2 consumer product manufacturing firms and 4 construction component manufacturers.

From 44 firm-point observations due to lack of the R&D expenditure in year 2008. Because the Stock exchanges of Thailand announce the new format of annual report and effective in year 2008. Then R&D expenditure is not shown in annual report since year 2008.

The data from annual report is used to calculate the VAIC^{TM} and data is used during year 2004 - 2007.

VAICe offers the constructs for the measurement of IC and the independent variables for regression analysis.

The dependent variables are manufacturing performance; Return on equity (ROE), Return on total assets (ROA), Growth in revenues (GR) and Employee productivity (EP).

Data sources

The data for this paper is mainly collected from primary sources. Data is available in the listed company's annual report which is published by the Stock Exchanges of Thailand. The data for the paper was collected from the SEC website (see www.sec.or.th) directly.

Independent variables	Dependent variables
VAIC	Return on equity (ROE)
Human capital	Return on total assets (ROA)
Structural capital	Growth in revenues (GR)
Innovation capital	Employee productivity (EP)
Capital employed	

Table I: Descriptive for Independent and Dependent variables.

Apply the statistic tool to investigate the hypotheses,

1. Test correlation between VAIC and Firm's performance to investigate H1a, H1b, H1c and H1d.

2. Test correlation between Independent variables.

3. Apply multi regression to investigate H2a, H3a, H4a and H5a.

$$ROE_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (1)$$

4. Apply multi regression to investigate H2b, H3b, H4b and H5b.

$$ROA_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (2)$$

5. Apply multi regression to investigate H2c, H3c, H4c and H5c.

$$GR_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (3)$$

6. Apply multi regression to investigate H2d, H3d, H4d and H5d.

$$EP_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (4)$$

VAIC™ and VAICe calculation result

Calculation value added; VA = Net sales revenue - Cost of good sold - Depreciation

Component calculation

VACA is indicator of VA efficiency of capital employed = VA ÷ CE
VAHU is indicator of VA efficiency of human capital = VA ÷ HU
STVA is indicator of VA efficiency of structural capital = SC ÷ VA
InCE is indicator of VA efficiency of innovation capital = R&D ÷ VA

VAIC™ Calculation method

Calculation formula: VAIC = VAHU + STVA + VACA + InCE

Company	Year	Value added (VA) = Net sale - Cost of good sold - Depreciation		
		Net sale revenue	Cost of good sold & Depreciation	VA
I	2004	56,466,840,000	55,485,820,978	981,019,022
	2005	58,536,010,000	55,160,150,000	3,375,860,000
	2006	77,698,450,000	73,752,400,000	3,946,050,000
	2007	93,824,680,000	89,150,610,000	4,674,070,000
II	2004	48,198,828,864	42,025,422,448	6,173,406,416
	2005	43,765,832,000	36,521,093,000	7,244,739,000
	2006	43,554,074,950	36,500,785,685	7,053,289,265
	2007	33,766,024,521	27,101,589,935	6,664,434,586
III	2004	154,546,000,000	126,862,690,000	27,683,310,000
	2005	187,132,000,000	163,463,310,000	23,668,690,000
	2006	205,360,000,000	185,090,000,000	20,270,000,000
	2007	227,518,000,000	216,635,420,000	10,882,580,000
IV	2004	644,693,550,000	580,097,700,000	64,595,850,000
	2005	926,269,340,000	828,567,400,000	97,701,940,000
	2006	1,213,985,280,000	1,098,970,750,000	115,014,530,000
	2007	1,495,806,220,000	1,379,228,810,000	116,577,410,000
V	2004	192,395,000,000	136,522,000,000	55,873,000,000
	2005	218,265,000,000	166,848,000,000	51,417,000,000
	2006	258,175,000,000	217,162,000,000	41,013,000,000
	2007	267,737,000,000	228,682,000,000	39,055,000,000
VI	2004	36,874,990,000	31,061,042,000	5,813,948,000
	2005	36,288,180,000	33,824,841,000	2,463,339,000
	2006	35,421,456,000	33,239,232,000	2,182,224,000
	2007	28,643,918,000	26,717,312,000	1,926,606,000
VII	2004	6,053,228,000	5,259,342,000	793,886,000
	2005	6,869,653,000	6,012,940,000	856,713,000
	2006	8,315,523,000	7,331,213,000	984,310,000
	2007	7,906,951,000	6,982,493,000	924,458,000
VIII	2004	20,843,000,000	13,610,000,000	7,233,000,000
	2005	21,304,000,000	15,585,000,000	5,719,000,000
	2006	22,630,000,000	17,331,000,000	5,299,000,000
	2007	24,926,000,000	19,099,000,000	5,827,000,000
IX	2004	16,639,260,000	14,265,170,000	2,374,090,000
	2005	18,042,750,000	16,857,970,000	1,184,780,000
	2006	18,853,810,000	17,682,500,000	1,171,310,000
	2007	31,139,060,000	27,423,650,000	3,715,410,000
X	2004	46,751,021,610	43,477,425,030	3,273,596,580

	2005	53,643,485,030	50,013,090,740	3,630,394,290
	2006	55,038,582,680	52,014,947,380	3,023,635,300
	2007	55,507,131,230	54,092,984,840	1,414,146,390
XI	2004	3,739,358,353	2,626,191,612	1,113,166,741
	2005	4,245,284,348	2,826,742,615	1,418,541,733
	2006	4,140,898,231	2,965,060,249	1,175,837,982
	2007	4,137,575,109	2,912,047,539	1,225,527,570

Table II: Value added calculation result (Unit: Baht).

Company	**Year**	**Capital employ (CE)**	**Expend human (HU)**	**VA - HU (SC)**	**Expend R&D (R&D)**
I	2004	26,229,650,000	570,180,000	410,839,022	633,000,000
	2005	25,987,480,000	1,092,730,000	2,283,130,000	718,000,000
	2006	33,118,650,000	1,238,390,000	2,707,660,000	690,000,000
	2007	44,056,240,000	1,955,120,000	2,718,950,000	746,000,000
II	2004	25,712,318,064	4,565,000,000	1,608,406,416	2,409,941,443
	2005	25,163,870,000	4,565,000,000	2,679,739,000	2,188,291,600
	2006	25,134,339,401	4,378,000,000	2,675,289,265	2,177,703,748
	2007	25,313,207,131	4,562,000,000	2,102,434,586	1,688,301,226
III	2004	146,723,000,000	4,100,260,000	23,583,050,000	33,000,000
	2005	128,277,000,000	4,288,200,000	19,380,490,000	63,500,000
	2006	128,098,000,000	4,876,000,000	15,394,000,000	59,100,000
	2007	130,814,000,000	6,108,000,000	4,774,580,000	65,500,000
IV	2004	483,815,480,000	3,999,632,883	60,596,217,117	151,540,000
	2005	638,277,790,000	4,017,649,113	93,684,290,887	202,220,000
	2006	728,856,550,000	4,673,602,108	110,340,927,892	190,080,000
	2007	859,825,150,000	5,140,740,190	111,436,669,810	526,020,000
V	2004	186,246,000,000	4,542,000,000	51,331,000,000	321,000,000
	2005	194,505,000,000	4,775,000,000	46,642,000,000	426,000,000
	2006	217,495,000,000	12,604,000,000	28,409,000,000	447,000,000
	2007	244,751,000,000	13,411,000,000	25,644,000,000	340,000,000
VI	2004	36,521,810,000	265,487,069	5,548,460,931	0
	2005	51,243,817,000	261,146,972	2,202,192,028	2,500,000
	2006	44,555,684,000	330,774,571	1,851,449,429	3,027,034
	2007	36,492,880,000	345,555,379	1,581,050,621	9,024,984
VII	2004	4,029,496,000	594,520,000	199,366,000	109,570,000
	2005	4,709,668,000	603,160,000	253,553,000	135,770,000
	2006	5,553,590,000	680,600,000	303,710,000	112,640,000
	2007	6,483,473,000	704,780,000	219,678,000	162,190,000
VIII	2004	71,575,000,000	1,116,383,478	6,116,616,522	4,536,131
	2005	70,699,000,000	1,403,414,513	4,315,585,487	4,046,763
	2006	68,458,000,000	1,635,029,000	3,663,971,000	30,736,604

	2007	75,377,000,000	2,289,430,000	3,537,570,000	16,295,753
IX	2004	21,995,710,000	372,710,000	2,001,380,000	14,000,000
	2005	22,087,410,000	292,800,000	891,980,000	12,000,000
	2006	20,663,640,000	335,790,000	835,520,000	7,000,000
	2007	23,423,350,000	351,530,000	3,363,880,000	20,000,000
X	2004	24,022,145,720	903,750,000	2,369,846,580	9,000,000
	2005	26,993,794,640	1,052,440,000	2,577,954,290	10,000,000
	2006	26,800,452,230	1,090,170,000	1,933,465,300	8,000,000
	2007	33,575,862,510	1,223,540,000	190,606,390	7,000,000
XI	2004	3,302,596,518	201,000,000	912,166,741	5,300,000
	2005	4,144,086,219	228,000,000	1,190,541,733	5,500,000
	2006	3,189,617,586	338,500,000	837,337,982	5,900,000
	2007	3,002,253,230	317,000,000	908,527,570	5,500,000

Table III: Annual report data for calculate VAICe (Unit: Baht).

Company	Year	Pre-tax income	Stock's equity	Total assets	Current year revenue	Last revenue
I	2004	1,992,720,000	8,292,200,000	26,229,650,000	56,466,840,000	29,086,570,0
	2005	2,020,500,000	10,322,190,000	25,987,480,000	58,536,010,000	56,466,840,0
	2006	2,845,530,000	12,595,580,000	33,530,500,000	77,698,450,000	58,536,010,0
	2007	3,443,460,000	13,943,860,000	44,430,240,000	93,824,680,000	77,698,450,0
II	2004	1,417,821,000	13,413,832,000	28,181,059,057	48,198,828,864	40,960,997,9
	2005	2,496,983,000	15,020,373,000	27,497,300,000	43,765,832,000	48,198,828,8
	2006	2,010,349,216	14,585,072,512	26,198,812,059	43,554,074,950	43,765,832,0
	2007	3,331,512,919	15,875,506,681	26,254,715,824	33,766,024,521	43,554,074,9
III	2004	18,128,000,000	20,368,000,000	146,723,000,000	156,147,000,000	96,135,000,0
	2005	29,493,000,000	76,311,000,000	128,277,000,000	206,292,000,000	156,147,000
	2006	8,945,000,000	82,953,000,000	128,098,000,000	209,452,000,000	206,292,000
	2007	14,138,000,000	90,415,000,000	130,814,000,000	232,307,000,000	209,452,000
IV	2004	95,749,220,000	184,914,960,000	487,226,230,000	644,693,550,000	489,713,410
	2005	123,079,510,000	278,432,930,000	649,806,660,000	926,269,340,000	644,693,550
	2006	160,801,350,000	354,322,360,000	751,453,470,000	1,213,985,280,000	926,269,340
	2007	165,434,790,000	398,651,520,000	892,351,470,000	1,495,806,220,000	1,213,985,28
V	2004	52,503,000,000	64,893,000,000	191,081,000,000	192,395,000,000	148,865,000
	2005	47,565,000,000	70,693,000,000	199,370,000,000	218,265,000,000	192,395,000
	2006	43,589,000,000	87,949,000,000	221,897,000,000	258,175,000,000	218,265,000
	2007	45,504,000,000	108,539,000,000	248,256,000,000	267,737,000,000	258,175,000
VI	2004	6,415,855,023	20,086,980,000	36,525,730,000	36,874,990,000	29,326,030,0
	2005	3,084,018,626	17,609,834,000	51,315,688,000	36,288,180,000	36,874,990,0
	2006	2,746,539,835	20,026,838,000	44,622,098,000	35,421,456,000	36,288,180,0
	2007	1,575,140,000	23,415,331,000	36,553,758,000	28,643,918,000	35,421,456,0
VII	2004	987,733,000	2,975,473,000	4,210,646,000	6,053,228,000	4,403,516,00

	2005	1,138,364,000	3,554,409,000	4,709,668,000	6,869,653,000	6,053,228,00
	2006	1,380,671,000	4,333,006,000	5,553,590,000	8,315,523,000	6,869,653,00
	2007	1,523,194,000	5,132,384,000	6,514,992,000	7,906,951,000	8,315,523,00
VIII	2004	4,103,000,000	35,120,000,000	71,575,000,000	20,843,000,000	19,016,000,0
	2005	1,522,000,000	35,893,000,000	70,699,000,000	21,304,000,000	20,843,000,0
	2006	2,780,000,000	49,144,000,000	68,458,000,000	22,630,000,000	21,304,000,0
	2007	2,331,000,000	57,656,000,000	75,377,000,000	24,926,000,000	22,630,000,0
IX	2004	1,499,960,000	10,470,320,000	21,995,710,000	16,639,260,000	10,087,050,0
	2005	456,320,000	10,742,600,000	22,087,410,000	18,042,750,000	16,639,260,0
	2006	898,230,000	13,868,730,000	20,663,640,000	18,853,810,000	18,042,750,0
	2007	3,287,130,000	16,711,210,000	23,423,350,000	31,139,060,000	18,853,810,0
X	2004	1,909,525,550	11,898,528,180	24,022,145,720	46,751,021,610	40,342,564,3
	2005	2,230,066,210	12,820,213,770	26,993,794,640	53,643,485,030	46,751,021,6
	2006	1,993,186,510	13,767,935,760	26,800,452,230	55,038,582,680	53,643,485,0
	2007	1,710,052,740	14,569,709,200	33,575,862,510	55,507,131,230	55,038,582,6
XI	2004	967,935,244	1,669,804,604	3,302,596,518	3,739,358,353	3,165,058,77
	2005	1,067,234,285	1,871,098,744	4,144,086,219	4,245,284,348	3,739,358,35
	2006	639,477,103	1,404,667,583	3,189,617,586	4,140,898,231	4,245,284,34
	2007	732,819,218	1,513,078,343	3,002,253,230	4,137,575,109	4,140,898,23

Table IV: Annual report data for calculate firm's performance (Unit: Baht (Except number employee)).

Independent variables					**Dependent variables**			
VACA	**VAHU**	**STVA**	**lnCE**	**VAIC**	**ROE**	**ROA**	**GR**	**EP$\times 10^6$**
0.0374	1.7205	0.4188	0.6452	2.8220	0.2403	0.0760	0.9413	0.2948
0.1299	3.0894	0.6763	0.2127	4.1083	0.1957	0.0777	0.0366	0.1928
0.1191	3.1864	0.6862	0.1749	4.1666	0.2259	0.0849	0.3274	0.2300
0.1061	2.3907	0.5817	0.1596	3.2381	0.2470	0.0775	0.2075	0.2541
0.2401	1.3523	0.2605	0.3904	2.2433	0.1057	0.0503	0.1767	0.0970
0.2879	1.5870	0.3699	0.3021	2.5469	0.1662	0.0908	-0.0920	0.1829
0.2806	1.6111	0.3793	0.3088	2.5797	0.1378	0.0767	-0.0048	0.1594
0.2633	1.4609	0.3155	0.2533	2.2929	0.2099	0.1269	-0.2247	0.2853
0.1887	6.7516	0.8519	0.0012	7.7934	0.8900	0.1236	0.6242	2.4287
0.1845	5.5195	0.8188	0.0027	6.5255	0.3865	0.2299	0.3211	3.9551
0.1582	4.1571	0.7594	0.0029	5.0777	0.1078	0.0698	0.0153	1.2502
0.0832	1.7817	0.4387	0.0060	2.3096	0.1564	0.1081	0.1091	2.2060
0.1335	16.1504	0.9381	0.0023	17.2244	0.5178	0.1965	0.3165	19.9187
0.1531	24.3182	0.9589	0.0021	25.4322	0.4420	0.1894	0.4368	25.7542
0.1578	24.6094	0.9594	0.0017	25.7282	0.4538	0.2140	0.3106	32.0385
0.1356	22.6772	0.9559	0.0045	23.7732	0.4150	0.1854	0.2321	22.5327
0.3000	12.3014	0.9187	0.0057	13.5259	0.8091	0.2748	0.2924	2.7590
0.2643	10.7680	0.9071	0.0083	11.9477	0.6728	0.2386	0.1345	2.2795
0.1886	3.2540	0.6927	0.0109	4.1461	0.4956	0.1964	0.1829	1.8446

0.1596	2.9122	0.6566	0.0087	3.7371	0.4192	0.1833	0.0370	1.8107
0.1592	21.8992	0.9543	0.0000	23.0127	0.3194	0.1757	0.2574	7.4258
0.0481	9.4328	0.8940	0.0010	10.3758	0.1751	0.0601	-0.0159	3.2670
0.0490	6.5973	0.8484	0.0014	7.4961	0.1371	0.0616	-0.0239	2.8112
0.0528	5.5754	0.8206	0.0047	6.4535	0.0673	0.0431	-0.1913	1.5736
0.1970	1.3353	0.2511	0.1380	1.9215	0.3320	0.2346	0.3746	0.7252
0.1819	1.4204	0.2960	0.1585	2.0567	0.3203	0.2417	0.1349	0.7614
0.1772	1.4462	0.3086	0.1144	2.0465	0.3186	0.2486	0.2105	0.5998
0.1426	1.3117	0.2376	0.1754	1.8674	0.2968	0.2338	-0.0491	0.6577
0.1011	6.4790	0.8457	0.0006	7.4263	0.1168	0.0573	0.0961	1.0081
0.0809	4.0751	0.7546	0.0007	4.9113	0.0424	0.0215	0.0221	0.3648
0.0774	3.2409	0.6914	0.0058	4.0156	0.0566	0.0406	0.0622	0.6163
0.0773	2.5452	0.6071	0.0028	3.2324	0.0404	0.0309	0.1015	0.4969
0.1079	6.3698	0.8430	0.0059	7.3266	0.1433	0.0682	0.6496	1.4285
0.0536	4.0464	0.7529	0.0101	4.8630	0.0425	0.0207	0.0843	0.4225
0.0567	3.4882	0.7133	0.0060	4.2642	0.0648	0.0435	0.0450	0.8151
0.1586	10.5693	0.9054	0.0054	11.6386	0.1967	0.1403	0.6516	2.7484
0.1363	3.6222	0.7239	0.0027	4.4852	0.1605	0.0795	0.1589	0.2186
0.1345	3.4495	0.7101	0.0028	4.2968	0.1739	0.0826	0.1474	0.2348
0.1128	2.7735	0.6395	0.0026	3.5285	0.1448	0.0744	0.0260	0.2172
0.0421	1.1558	0.1348	0.0049	1.3376	0.1174	0.0509	0.0085	0.1729
0.3371	5.5381	0.8194	0.0048	6.6994	0.5797	0.2931	0.1814	0.6974
0.3423	6.2217	0.8393	0.0039	7.4071	0.5704	0.2575	0.1353	0.6854
0.3686	3.4737	0.7121	0.0050	4.5595	0.4553	0.2005	-0.0246	0.2959
0.4082	3.8660	0.7413	0.0045	5.0200	0.4843	0.2441	-0.0008	0.3298

Table V: Descriptive for VAIC^{TM} ,VAICe and firm's performance.

EMPIRICAL RESULTS

To apply statistical tool by following each hypotheses test, results show;

1. Test correlation between VAIC and Firm's performance to investigate H1a, H1b, H1c and H1d.

	VAIC	ROE	ROA	GR
ROE	0.395			
	0.008			
ROA	0.311	0.791		
	0.040	0.000		
GR	0.302	0.325	0.159	
	0.046	0.032	0.303	
EP	0.875	0.299	0.282	0.251
	0.000	0.049	0.064	0.101

Cell Contents: Pearson correlation
P-value

Table VI: Correlation table between VAIC and Dependent variables
P-Value < 0.01 Strong correlation. (99% Confidence interval)
P-Value < 0.05 Correlation. (95% Confidence interval)

Intellectual capital effect to manufacturing performance

H1a. VAIC^{TM} positive associated with ROE	Yes, strong positive correlation.
H1b. VAIC^{TM} positive associated with ROA	Yes, positive correlation.
H1c. VAIC^{TM} positive associated with GR	Yes, positive correlation.
H1d. VAIC^{TM} positive associated with EP	Yes, strong positive correlation.

VAIC is positively affected to all manufacturing firm's performance. Firm can use VAIC as a measurement tool to measure the intellectual capital in the organization. Benchmarking also can applied both internal and external. Value of VAIC is positively related to the firm's performance and they can improve the VAIC value to increase their firm's performance. This result show IC trend and a firm's performance trend go with the same direction.

2. Test correlation between Independent variables.

	VAHU	STVA
STVA	0.693	
	0.000	
InCE	-0.359	-0.609
	0.017	**0.000**

Cell Contents: Pearson correlation
P-value

Table VII: Correlation table between Independent variables
P-Value < 0.01 Strong correlation. (99% Confidence interval)
P-Value < 0.05 Correlation. (95% Confidence interval)

Relationship between sub-capitals

H2. Structural capital associated with Innovation capital	Yes, strong correlation.
H3. Structural capital associated with Human capital	Yes, strong correlation.
H4. Human capital associated with Innovation capital	Yes, correlation.

Base on the theory of multi regression analysis, independent variables must verified the correlation before apply in the regression model. From the result, structural capital, human capital and innovation capital are correlated. So the model should have only one sub-capital in each model by the way the study is applied multi regression model to see the relationship of each capital to the firm's performance. Researcher do not use the model for predict the new value so all independent variables can be use in model and see the coefficient and P-value for judgment the relationship.

3. Apply multi regression to investigate H2a, H3a, H4a and H5a.

$$ROE_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (1)$$

Independent variable	Coefficient	t-statistic	P-value
Constant	-0.0488	-0.44	0.663
VACA	**1.3112**	5.29	**0.000**
VAHU	0.0095	1.88	0.068
STVA	0.1010	0.62	0.536
InCE	-0.0619	-0.28	0.780
Notes: Adjusted R^2 = 45.9%; F-value = 10.12 (P-value < 0.0001)			

Table VIII: Regression result of ROE and Independent variables.

P-Value < 0.01 Strong associated. (99% Confidence interval)
P-Value < 0.05 Associated. (95% Confidence interval)

H2a. Innovation capital positive associated with ROE No.
H3a. Human capital positive associated with ROE No.
H4a. Structural capital positive associated with ROE No.
H5a. Capital employed positive associated with ROE Yes, strong associated.

Innovation, human and structural capital are not positively affected to ROE. Capital employed (VACA) is positively affected to ROE. Increase value of VACA is also increasing ROE. Base on calculation formula of VACA, VACA = VA ÷ (Total assets – Intangible assets), firm should be increase VA and Intangible assets to increase VACA value. By the way the intangible assets are the one of innovation capital outcome. Firm should monitor on the R&D expenditure and see the outcome in term of intangible assets increasing.

4. Apply multi regression to investigate H2b, H3b, H4b and H5b.

$$ROA_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (2)$$

Independent variable	**Coefficient**	**t-statistic**	**P-value**
Constant	0.0936	2.30	0.027
VACA	**0.5873**	6.47	**0.000**
VAHU	**0.0061**	3.30	**0.002**
STVA	-0.1246	-2.10	0.042
InCE	-0.1387	-1.73	0.092
Notes: Adjusted R^2 = 54.1%; F-value = 13.68 (P-value < 0.0001)			

Table IX: Regression result of ROA and Independent variables.

P-Value < 0.01 Strong associated. (99% Confidence interval)
P-Value < 0.05 Associated. (95% Confidence interval)

H2b. Innovation capital positive associated with ROA No.
H3b. Human capital positive associated with ROA Yes, strong associated.
H4b. Structural capital positive associated with ROA No.
H5b. Capital employed positive associated with ROA Yes, strong associated.

Innovation and structural capital are not positively affected to ROA. Human capital (VAHU) and Capital employed (VACA) are positively affected to ROA. Increase value of VACA and VAHU are also increasing ROA. Base on calculation formula of VACA, VACA = VA ÷ (Total assets – Intangible assets) and VAHU, VAHU = VA ÷ Total expenditure on employees. Firm should be increase VA and Intangible assets to increase VACA and VAHU value. Increasing of intangible assets is the key factor of increasing both ROA and ROE. Base on VAHU formula, Firm should

not reduce the expenditure on employee because morale and motivation of employees are reduced.

5. Apply multi regression to investigate H2c, H3c, H4c and H5c.

$$GR_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 InCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (3)$$

Independent variable	**Coefficient**	**t-statistic**	**P-value**
Constant	-0.1314	-0.88	0.385
VACA	-0.3359	-1.01	0.320
VAHU	0.0079	1.17	0.251
STVA	0.3612	1.66	0.106
InCE	**0.8719**	2.95	**0.005**
Notes: Adjusted R^2 = 19.0%; F-value = 3.52 (P-value < 0.05)			

Table X: Regression result of GR and Independent variables.

P-Value < 0.01 Strong associated. (99% Confidence interval)
P-Value < 0.05 Associated. (95% Confidence interval)

H2c. Innovation capital positive associated with GR	Yes, strong associated.
H3c. Human capital positive associated with GR	No.
H4c. Structural capital positive associated with GR	No.
H5c. Capital employed positive associated with GR	No.

Human, structural capital and capital employed are not positively affected to GR. Innovation capital (InCE) is positively affected to GR. Increase value of InCE is also increasing GR. Base on calculation formula of InCE, InCE = R&D expenditure ÷ VA. Firm should be increase on R&D expenditure to increase InCE and the outcome of the R&D should be positively affected to intangible assets. By the way growth in revenues is also relate to the VA value because the VA is from calculation formula; VA = Net sale revenue – Cost of good sold – Depreciation. Sale revenue growth means Net sale revenue increasing.

6. Apply multi regression to investigate H2d, H3d, H4d and H5d.

$$EP_{it} = \alpha_0 + \alpha_1 VACA_{it} + \alpha_2 lnCE_{it} + \alpha_3 VAHU_{it} + \alpha_4 STVA_{it} + \varepsilon_{it} \quad (4)$$

Independent variable	Coefficient	t-statistic	P-value
Constant	2.942	1.27	0.212
VACA	-4.994	-0.97	0.339
VAHU	**1.221**	11.52	**0.000**
STVA	-9.243	-2.74	0.009
InCE	-0.872	-0.19	0.850
Notes: Adjusted R^2 = 80.4%; F-value = 45.18 (P-value < 0.0001)			

Table XI: Regression result of EP and Independent variables.

P-Value < 0.01 Strong associated. (99% Confidence interval)
P-Value < 0.05 Associated. (95% Confidence interval)

H2d. Innovation capital positive associated with EP	No.
H3d. Human capital positive associated with EP	Yes, strong associated.
H4d. Structural capital positive associated with EP	No.
H5d. Capital employed positive associated with EP	No.

Human capital (VAHU) is only one sub-capital which positively affected to EP. Increase value of VAHU is also increase EP. Base on calculation formula of VAHU, VAHU = VA ÷ Total expenditure on employees. Firm should be increase VA to increase VAHU value. To maintain morale and motivation, firm should not reduce on the expenditure of employees. The conclusion section is provided summary of all relationship and strategic of increasing the intellectual capital in manufacturing firm.

CONCLUSION

In the new economics knowledge, the productivity of manufacturing is not only from labor intensive but also the knowledge of workers. They are the significantly contribution of the manufacturing firm value added. This paper uses the measurement tool in term of value added to define how the intangible assets also known in the name of intellectual capital contribute to the manufacturing firm's performance. The conclusion the author found from the empirical model and the measurement tool is that "Intellectual capital has a very strong positive effect on the manufacturing firm performance". And as the author goes deep down to details of each sub-capital, the innovation capital has positive effect to the growth in revenue. The growth in revenue is concern with the customer. R&D is more focused on what the customer want, need or goes beyond the customer expectations. What we call quality is one part of innovation capital.

The results of this paper show capital employed affects to the return on equity and return on total assets. The human capital also affects the employee productivity and the return on total assets. Manufacturing firms should be more focused on the human capital development and prepare the high performance equipments to increase productivity. This paper proved that intellectual capital measurement tool can be applied to the manufacturing firm.

The measurement method can be adopted in manufacturing firm to benchmark internally and externally in the industry and set strategies to improve each sub-capital and increase the intellectual capital for sustaining a competitive edge.

Result summary

VAIC positively affects to ROE, ROA, GR and EP.
VACA (Capital employed) positively affects to ROE and ROA.
VAHU (Human capital) positively affects to ROA and EP.
InCE (Innovation capital) positively affects to GR.

To focus on the result, author selects a research which has similar dependent and independent variables to compare results with this paper. A conclusion of positively relationships between dependent and independent is shown in Table XII.

Researchers	**Independent variables**	**Dependent variable**	**Comparable result**	**Different result**
Chen, Cheng and Hwang (2005)	VAIC VACA VAHU STVA R&D	ROE ROA GR EP	VAIC and ROE, ROA, GR, EP VACA and ROE, ROA VAHU and ROA, EP InCE (R&D) and GR	VACA and GR, EP VAHU and ROE, GR, EP InCE and GR VAHU and EP
Kamath (2008)	VACA VAHU SCVA	ROA	VACA and ROA VAHU and ROA	-
Chan (2009)	VAIC VACA VAHU STVA	ROE ROA	VAIC and ROE, ROA VACA and ROE, ROA	VAHU and ROA

Table XII: Result comparison with prior research.

Based on the finding of this paper and compare to the prior research, it can be proved that intellectual capital or intangible assets strongly affect to manufacturing firm's performance.

Manufacturing firm can applied VAIC to measure intellectual capital in the organization. Benchmarking also can be use both internal and external organization for improvement and enhance the firm's performance.

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CASE STUDY: PERFORMANCE MEASUREMENT IN A WALES BASED CONSTRUCTION COMPANY – OPCO.

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ABSTRACT

There are a vast amount of studies on performance measurement in general, for manufacturing and service sectors. However, very few studies were reported on performance measurement of business processes in a construction industry. This paper describes how a Wales based Construction Company are working towards the design and implementation of a unique performance measurement model for measuring business processes. This model will help to improve overall organisational performance, and in order to achieve this goal we focused mainly on four elements namely People, Communication, Process and Technology. By carefully implementing Statistical Process Control Technique (to check process performance) and Mobile Computing Technology (to capture primary and secondary data, which in later stages feed into statistical process control model to generate individual process or overall organisational performance).

This model can be applicable to not only within the construction industry, but for any organisation determined in achieving productivity by practicing quality methods through strategic change management, which is described in the paper.

Keywords: Performance Measurement System, Business Process Management, Statistical Process Control, Mobile Computing System, Construction Industry

INTRODUCTION

Designing performance measurement system to measure business processes is very complex, challenging and yet very important for any organisation to increase its overall efficiency. There is vast amount of literature available on performance measurement of business processes for non – construction industry [21]. However, this aspect is unexplored in construction industry because of its complex nature [10, 39]. Hayes [28] stated *"construction sector is facing same problems that the manufacturing sector faced in 1980's".*

Research back ground:

Performance measurement system is an interesting research topic for both organisations and academicians [10]. Most of the organisations measure performance based on traditional methods [15, 19] like analysing financial reports etc. Many researchers [10, 19, 28, 35] find this approach wrong because financial reports depicts organisational performance of only past and does not help in measuring present and predicting future performance. [22, 28] Many researchers [8, 11, 12, 16, 18, 26] criticised the financial

performance measurement model and felt the need to improve efficient model which can increase quality and flexibility by reducing lead time and wasteful costs [19, 34]. Since then both business practitioners and researchers are trying to design a perfect model [8, 10, 19]. The ability to measure the performance of operations is very critical for the construction industry, as majority (core) of its business purely depends on operational activities.

Usually many companies implement performance measurement strategy only for the lower management levels [25, 40] and expect change throughout the organisation. Recent literature points out [3, 12, 16, 28, 33, 42], that the common reason for failures in implementing performance measurement system are mainly due to top management's resistance to support the strategic change process. Performance measurement is not a quick fix tool; its main purpose is to monitor long term plans by measuring business processes regularly [2, 6, 25, 36] (not only core processes but also supporting processes) and to deliver validated information for the management to support decision making [39, 6, 19]. Enough caution should be taken [4, 12, 16, 32] during design and implementation phase, because it is very important to choose what to measure (KPI's), how to measure (data collection and process analysis) and when to measure (time intervals).

Yadam's research developed a casual relationship between performance measurement system (of business processes), statistical process control and mobile computing system. If design is implemented and used appropriately, there are high chances of achieving competitive edge by increasing the efficiency of an organisation at all levels.

Hence the main aim of this research is to design a robust PMS (performance measurement system) model for the construction industry to achieve efficiency. Next section provides updated literature review to support the PMS model followed by research methodology. Finally, paper includes a discussion of the model, conclusion and recommendations for both practitioners and researchers.

Company Background:

Formed in July 2001 OPCO is a UK based multi disciplinary contractor that specialises in the designing and construction of high value buildings for national and international clients. OPCO has developed an enviable reputation for delivering quality high rise residential, commercial buildings, industrial, process engineering facilities, public sector works and leisure complexes by having strong site, commercial and design management providing assurance to clients that their projects will be delivered within agreed project timelines and budgets with high quality standards and safety.

Opco's aim is to be distinctive. This means being different from its competitors - and, in key respect, better than its competitors. It is very important to give clients reason for choosing OPCO in the first place, and the reason to keep them coming back. Delivering on time, within budget and right level of quality is not enough to achieve competitive edge. These goals are important, but every contractor in this industry aspires for them. In order to be distinctive, and better, OPCO deeply concentrates on four key areas of its business, namely people, communication, process and technology.

A crucial part of Opco's distinctiveness is the implementation of Deming's 14 points into its corporate culture right from the start which are also Opco's 14 visions and working hard to continuously improve its business processes and systems to withstand the internal and external uncertainties. This always helped opco to increase its quality and productivity by reducing non value added activities in the business to a great extent.

LITERATURE – BACKGROUND

This chapter gives an overview of current literature on Performance Measurement systems ***[PMS]*** (to measure business processes), Mobile Computing System ***[MCS]*** (for data capture) and Statistical Process Control ***[SPC]*** (for analysing data, previously captured through MCS).

Performance Measurement System [PMS]:

It is very important for organisations to analyse how their performance is measured and how they communicate performance strategy with their market audience [14], for example: stake holders, employees and customers. Mostly organisations measure performance based on traditional methods [15, 19] like analysing return on investment (ROI), profit per unit produced and financial reports. Many researchers [28, 10, 19, 35] feel, this approach is totally wrong and misleading because financial reports only shows information happened in past but does not help in measuring present and predicting future performance. The main disadvantage according to ghalayini & noble cited in [14], is that *"Traditional performance systems based on financial reports encourages short term thinking; lack strategic focus and fail to provide data on quality, responsiveness and flexibility; encourages local optimisation; do not encourage continuous development; reports organisational performance not current performance".* [28, 22] Many researchers [8, 26] criticised the financial performance measurement model and felt the need to improve an efficient model, which can increasing quality and flexibility by reducing lead time and wasteful costs [34, 19]. Since then both business practitioners and researchers are trying to design a perfect model [8, 10, 19]. The ability to measure the performance of operations is very critical for the construction industry, as majority (core) of its business purely depends on operational activities.

A success of design and implementation of an efficient performance measurement system depends on various factors [17] like:

1) *Qualitative*: based on human judgement
2) *Quantitative*: based on physical measures
3) *Attribute*: when a characteristic such as defect is measured as either present or not.
4) *Variable*: When measured on continuous scale.

Performance Measurement Models:

Balanced Scorecard [BSC]:

This is a very popular [28] and widely used performance measurement system. This model has four elements (Procedural framework) namely people, process, finance & training [17].

The objectives and measures of the scorecard are derived from an organisation's vision and strategy. This model incorporates four main measurement categories each of which with a wider range of potential sub-measures. It includes various lagging and leading indicators, but the only drawback is that it does not show any relationship between the measures. It is very important to establish relationship between indicators because it will help the management to analyse data in different dimensions and take productive decisions.

Performance Prism:

Performance prism is an improved version [28] of balanced scorecard model. This model deals with concerns of stakeholders like investors, suppliers, customers, employees and so on. According to [14], "It consists of five sections,

1) Stakeholder Satisfaction: who are our key stakeholders and what are their needs?
2) Strategies: what strategies must we put in place to meet these various needs?
3) Processes: what critical processes must be built or re-designed to execute these strategies?
4) Capabilities: what capabilities do we need to operate and further develop (processes)?
5) Stakeholder Contribution: what contribution do we expect from our stakeholders if we are to develop, maintain and enhance these capabilities?"

Performance Metrics:

A good performance measurement system depends on its performance metrics [14]. It is very important to design metrics as they are the links (build relationship) between various perspectives that an organisation decide to implement. This relationship between the performance management system and the metrics used do not relate to the strategic goals of the organisation. Ghalayini & Noble cited in [14] states that *"The danger of measuring the wrong things right when the sole purpose of an exercise is to design performance metrics, which might not necessarily, related to strategy".* This can usually occur when a large number of performance metrics is present in an organisation where "everything is measured but little that matters", 1996 state that this is not only necessary but it is performed at a great expense to the organisation, in terms of the efforts made to capture and manage the necessary data.

Performance Measurement in construction:

Today's construction industry still relies on traditional methods to measure performance. The major problem in construction industry is the amount of resources wasted due to its complex nature. Nudurupati [28] stated "The main weakness for construction industry is the logistics, material and information flow. Approximately 40% - 50% wasted due to different actors with their own time plans, 50% due to non production activities on site and 80% on purchase order rush. In order to overcome this problem Construction best practise programme [CBPP] launched 12 headline KPI's [28, 14]. These are meant to measure the business performance efficiently. The 12 KPI's are as follows

Table 1: Construction best practise programme - 12 headline KPI's [28, 14]

01 – Defects	07 - Predictability of design
02 – Safety	08 - Cost of design
03 – Productivity	09 - Customer satisfaction – product
04 – Profitability	10 - Customer satisfaction – services
05 – Construction cost	11 - Predictability of construction cost
06 – Construction time	12 - Predictability of construction time.

But Nudurupati [28] and few more researchers criticised the above named KPI's, "are lagging factors and they do not provide opportunity for change and do not predict future performance".

Mobile Computing System [MCS]:

According to Chen and Kamara [5], "In the recent years, construction information management has greatly benefited from advances in information and communications technology through increasing the speed of information flow, enhancing the efficiency and effectiveness of information communication and reducing the cost of information transfer". As we know the construction industry is very complex in nature, it is very important to manage communication efficiently. Ineffective communications can lead to negligence of important issues that require a quick response, which may result in on site decision being deferred [5].

Many researchers focused and developed various tools like electronic document management systems, knowledge management systems and web-based project management systems to [5], "reduces construction time, capital cost of construction, reduction in operation and maintenance cost, reduction in defects, reduction in accidents, reduction in waste, increase in productivity and increase in predictability". Yet the potential of mobile computing Technology in construction industry is not fully exploited and adopted broadly.

The main barriers for using mobile computing technology in construction industry are as follows,

1) Hardware: Screen Size, Resolution, Processing Capabilities and Input Methods.
2) Nature: Complex Industry.
3) High Setup Cost: Software, Equipment And Employee Training Cost are High.

Statistical Process Control [SPC]:

According to Grant & Leavenworth cite in [32] stated that "statistical process control is a statistical method for analysing certain product characteristics to determine the likelihood that improvement can be made in the process to reduce variability and achieve higher quality". The additional benefit is that it can be used to provide feedback to the process and develop wherever necessary.

SPC is a statistical based analysis method that is used to analyze process data and it is hoped, assist the process or control engineer in making improvement to the process. A statistical analysis of quality measurement should reveal any assignable cause variation.

Following are the statistical tools required for successful implementation and maintenance [Rienzo]:

- **Flow Diagrams:** To understand process.
- **Control Charts:** To monitor the process performance.
- **Scattered Diagram:** To check process behaviour.
- **Histogram and Pareto Charts:** To monitor defect frequency rate.
- **Cause and Effect Diagram:** To understand the relation between business components.

RESEARCH METHODOLOGY

Research Objective:

Yadam's research developed a casual relationship between performance measure (of business processes through) statistical process control and mobile computing Technology. If design is implemented and used appropriately, there are high chances of achieving competitive edge. Hence the object of this paper is to design a robust PMS model for the construction industry. Finally paper includes a discussion of the model conclusion and future recommendations for practitioners and the researchers.

Research Strategy:

According to the literature and information gathered, ***Action Research*** seems more relevant to this research. Many scholars defined action research in different ways [30]. According to Stefan & Goran [36] "Action Research means a research practice and a business practice integrating to achieve a common goal". During this process, the researcher has to make sure his research objectives are matching with the organisation objectives (goals or outcomes). The following diagram illustrates the process of action research in simple.

Figure 1: Action Research Method in Simple.

The above diagram explains how researcher and business practitioner come together and achieve common goals. It is very evident that, this is best practice in this research.

Data Collection:

The data for this research was gathered through various sources. This action research was conducted through

1) Interviews, Group Discussions
2) Analysis of Organisation Internal Documents.
3) Online Research.

DISCUSSION

Designing performance measurement system to measure business process in a construction industry is very difficult due to its complex nature. The modern construction industry is still using traditional performance measurement (financial). Many researchers stated that this is risky and totally wrong approach of performance measurement because financial measures only shows the performance in past, and do not help in measuring present and predicting future performance trends. The efficient performance measurement system must consider both the financial and non-financial measures.

Opco Performance Measurement Model:

The Opco's performance measurement model uses mobile computing technology at site level and web-based technology at office level to capture data. The captured data is then fed into the statistical process control tool to study the variations in the business processes and later report to top management for their decision making purpose. Following is the Opco's performance measurement model.

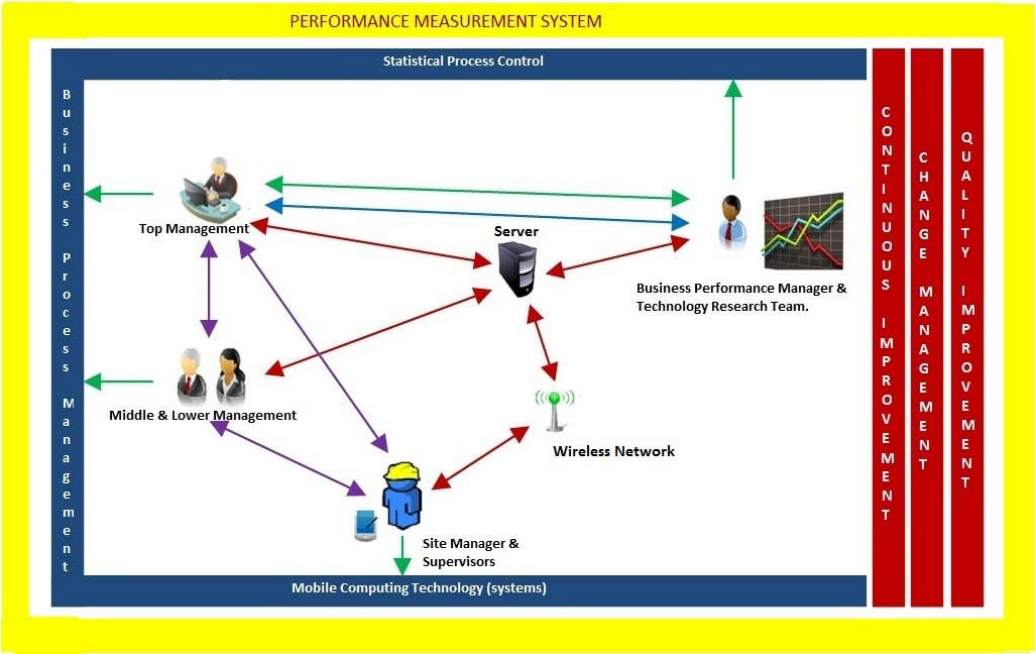

Figure 2: Opco's Performance Measurement Model.

The above performance measurement model is divided into four working phases, as follows:

1) The first phase represents data capture (red lines),
2) Second phase represents analysis of process behaviour, reporting to top management and capturing data (blue and red lines),
3) Third phase represents consultation between top management and other management levels to solve problematic areas (violet lines) and data capture (red lines),
4) The fourth phase represents reengineering of business processes (green lines) and data capture (red lines).

The following figure clearly illustrates the working process of Opco's performance measurement model.

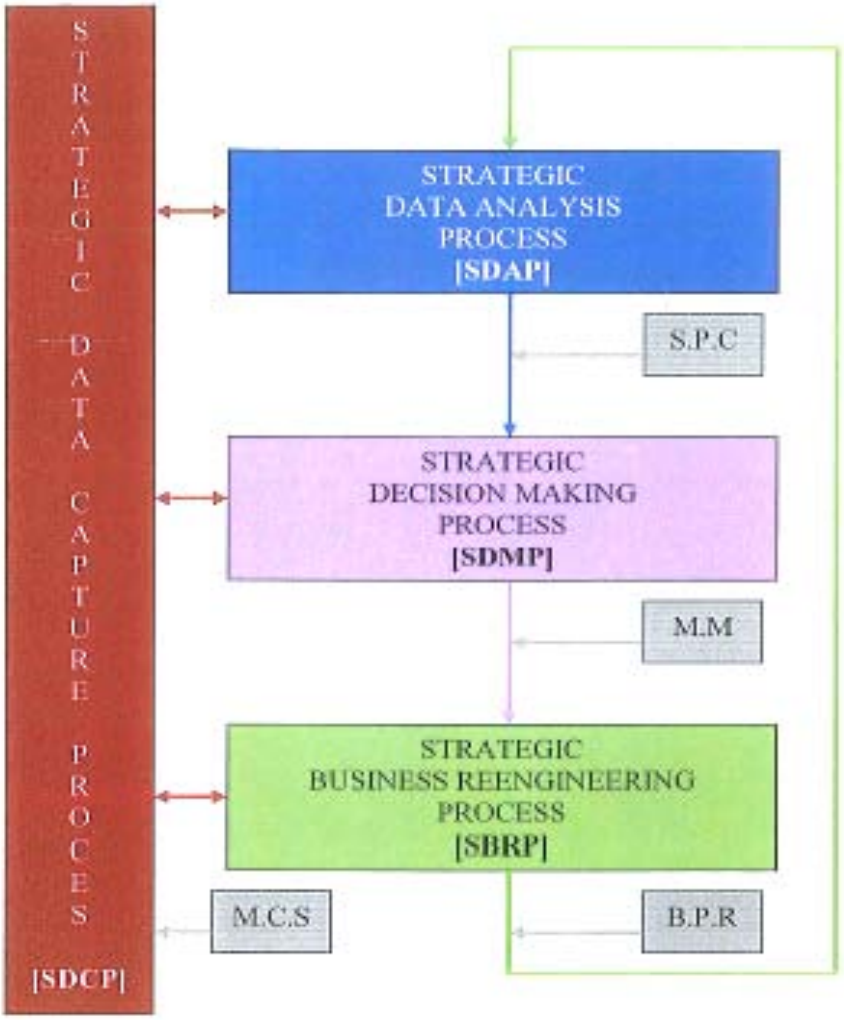

Figure 3 : Opco Performance Measurement Model – Working Process.

As we can see, every phase is a process itself and it is driven by powerful tool. The tools are as follows

1) M.C.S – Mobile Computing Technology (Systems).
2) S.P.C – Statistical Process Control.
3) M.M – Meeting Matrix.
4) B.P.R – Business Process Reengineering.

Opco Performance Measurement Model – Phase 1:

The main objective of this phase is to capture data. Capturing data is the base for this model because if the data collected is not accurate (gaps), the analysis will not be accurate. This will lead to wrong decision making and results in business failure. Firstly, a very efficient data capture strategy must be in place to monitor the data capture process across the business and secondly, it should be flexible and realistic in nature.

The major problem in this phase is to capture data accurately at site level. Many sites face the connectivity problems; this will lead to reduction in the speed of information flow (effecting the efficiency of information communication) and increasing the cost of information transfer. As we know the construction industry is very complex in nature, it is very important to manage communication efficiently. Ineffective communications can lead to negligence of important issues that requires a quick response, which may result in on site decision being deferred [5].

Following is the Opco's performance measurement model – phase 1.

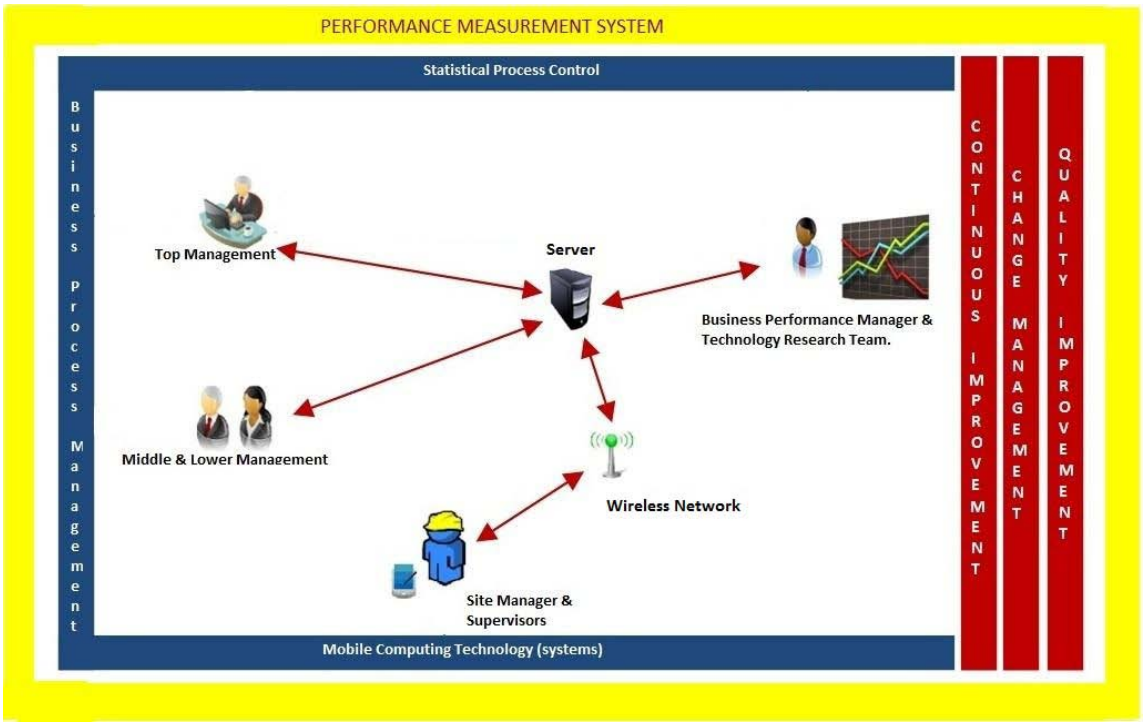

Figure 4: Opco Performance Measurement Model – Phase 1.

As we can see, everybody takes part in capturing data (red lines). The office based employees capture data and stores onto the server directly but the site based employees' captures the data using mobile computing technology and stores data onto the server. It is advised to continuously monitor data capture strategy in order to avoid information gap, which will destroy the whole measurement process.

Opco Performance Measurement Model – Phase 2:

The main objective of this phase is to analyse process behaviour, report to top management and to capture data continuously. Firstly, the performance manager analyse captured data using statistical process control tools to report (top-management) the variations (behaviour) of the processes. A statistical analysis of quality measurement should reveal any assignable cause variation.

In order to complete phase 2 operations successfully, we need statistical tools like

- Flow Diagrams: To understand process.
- Control Charts: To monitor the process performance.
- Scattered Diagram: To check process behaviour.
- Histogram and Pareto Charts: To monitor defect frequency rate.
- Cause and Effect Diagram: To understand the relation between business components.

Following is the Opco's performance measurement model – phase 2.

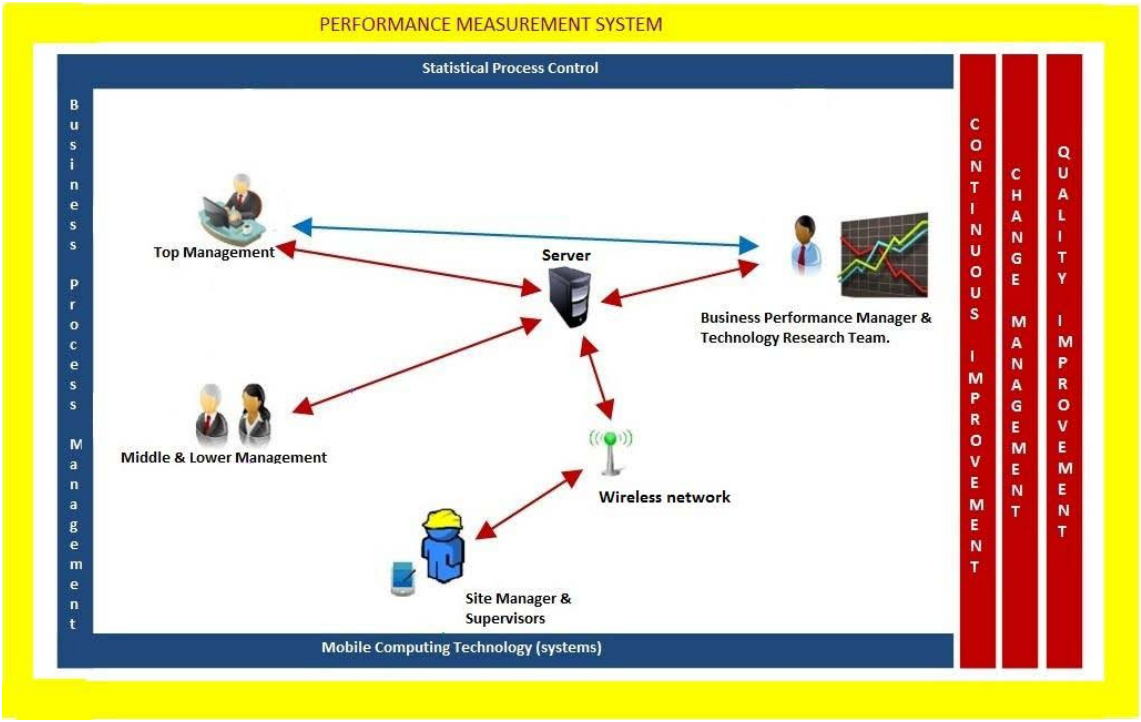

Figure 5: Opco Performance Measurement Model – Phase 2.

As we can see, this phase is divided into two parts. First part shows how the performance manager receives captured data from the server then analyse it using statistical tools and report to the top – management (blue line). Second part shows how everybody is participating in data capture strategy (red lines).

Opco Performance Measurement Model – Phase 3:

The main objective of this phase is for the top management to consult middle and lower management to discuss the problematic areas in the business processes and to capture data continuously. It is very important to have communication strategy (meeting matrix) in place; this will reduce the lead time and uncertainty by increasing the efficiency of decision making, planning and operations.

Majority of the decisions are taken during these meetings and it is advisable to make changes only if top management and the process owner mutually agree to the changes. And

the agreed changes must be reported back to the performance manager to commence process reengineering phase and change process.

Following is the Opco's performance measurement model – phase 3.

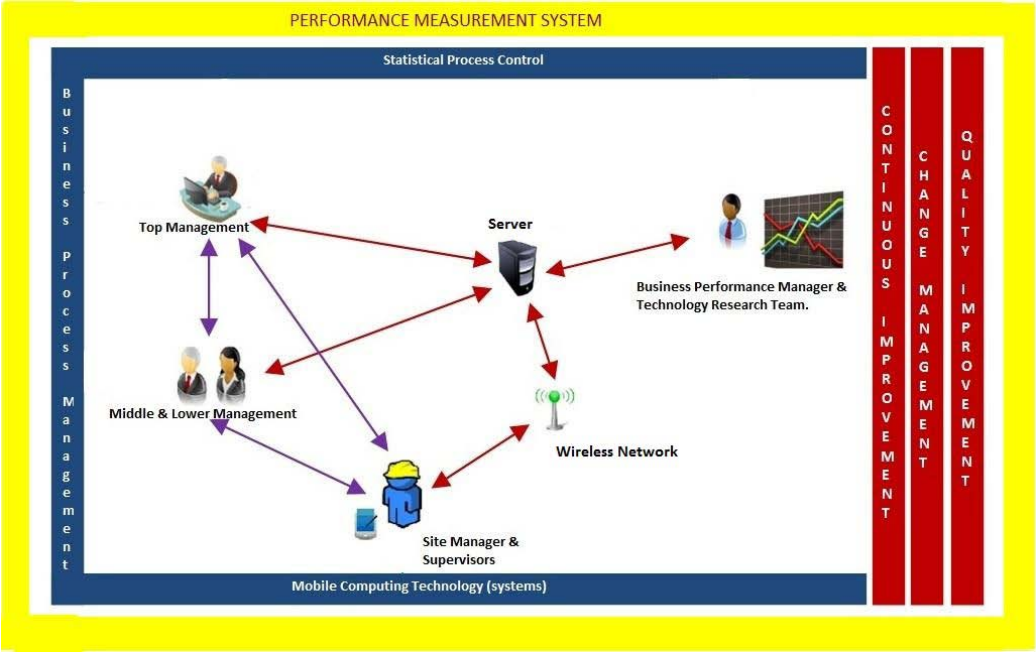

Figure 6: Opco's Performance Measurement Model – Phase 3.

As we can see, this phase is divided into two parts. First part shows how all the employees communicate across the organisation (violet line). Second part shows how everybody is participating in data capture strategy (red lines).

Opco's Performance Measurement Model – Phase 4:

The main objective of this phase is to reengineer business processes (by all) and to capture data continuously.

Following is the Opco's performance measurement model – phase 4.

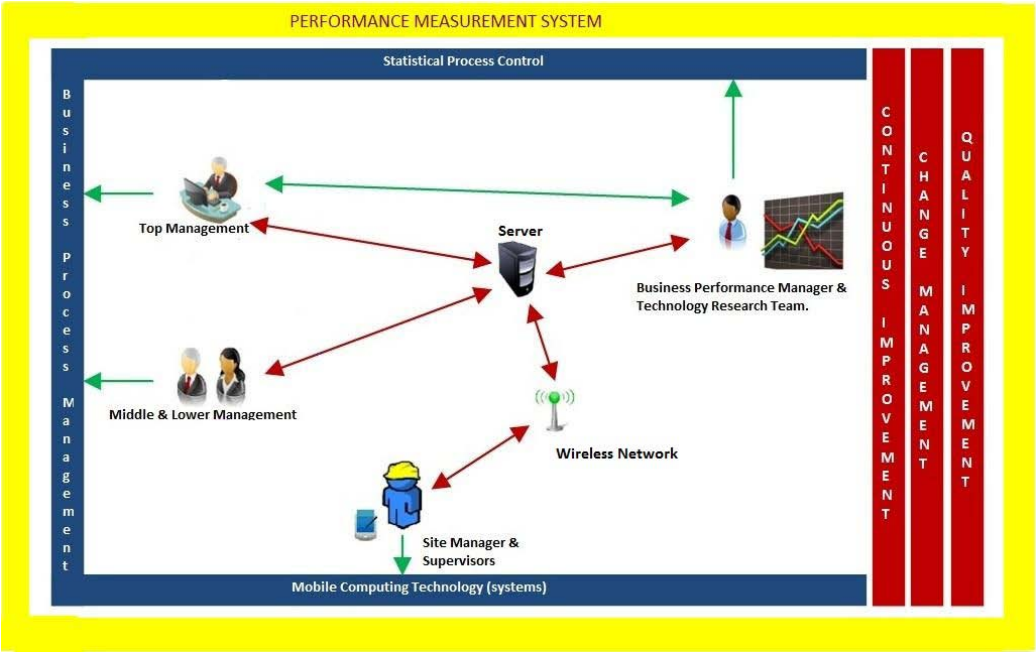

Figure 7: Opco's Performance Measurement Model – Phase 4.

As we can see, this phase is divided into two parts. First part shows how all the employees involved in change process through reengineering business processes (green line). These green lines show how everybody's working as a team to expand horizons in all directions. Second part shows how everybody is participating in data capture strategy (red lines).

Summary:

This section summarises the whole working process of Opco's performance measurement model.
Phase 1 : Capture data using web-based project management system (office level) and mobile computing technology (site level).
Phase 2 : Analysis of captured data using statistical process control tools, reporting to top-management and data capture.
Phase 3 : Top-management consults other employees regarding the performance reports, mutually agrees to the proposed changes to the processes and data cature takes place normally.
Phase 4 : Reengineering business processes across the organisation and data capture.

As you can see data capture never stops throughout the process

Table 1 : Summary of Opco's Performance Measurement Model.

	Phase 1	Phase 2	Phase 3	Phase 4
Analysis				
Decision Making				
Process Reengineering				
Data Capture				

CONCLUSION & RECOMMENDATIONS

The main aim of this research is to design a robust performance measurement model for the construction industry to achieve competitive edge by increasing the efficiency of an organisation at all levels.

It is very difficult to design performance measurement model to study business process behaviour in a construction industry because of its complex nature. Majority of the companies are still using traditional (financial) performance measurement models. It is very risky to make decisions based on the traditional measures because it provides past information and do not provide present performance and future forecasting. Usually companies implement performance measurement system at lower management levels, it is a must to implement it across organisation. But majority of the organisations face resistance from top management to support strategic change management.

A good performance measurement system depends on its performance metrics and it is very important to set the metrics right. The danger of measuring the wrong things right when the sole purpose of an exercise is to design performance metrics, which might not necessarily, related to strategy. This can usually occur when a large number of performance metrics is present in an organisation where “everything is measured but little that matters”.

Finally, the recommendations for both the researchers and practitioners are as follows

1) Performance Measurement System must be implemented at all levels of the organisation to maximise efficiency.

2) Performance Measurement System needs to establish relationship between various measures and promote conscious management of inevitable conflicts.

3) Performance Measurement System must facilitate continuous improvement in line with the strategic objectives of the business

4) Should try to avoid following traditional accounting based performance measures solely and to integrate it with the non-financial performance measures under one system.

5) Performance Measurement System design should consider mobile computing technology and web-based information systems capabilities to provide necessary level of data in terms of accuracy and reliability.

6) Performance Measurement System design should consider the organisational, behavioural and cultural aspects of the organisation concerned [2].

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CRITICAL PERFORMANCE ATTRIBUTES OF THAI AUTOMOTIVE SUPPLY CHAINS

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ABSTRACT

The Thai automotive industry has been ranked one of the top ten of the Thai export products for several years. Effective supply chain management has become a key strategy for the industry to stay competitive. Performance measurement has thus become a crucial issue in automotive supply chains. The purpose of the research is to gain insight into the relevant performance attributes that affect the automotive supply chains. The critical factor indexes (CFIs) are calculated in order to determine which of the performance attributes are considered to be the strength and which ones need to be specially focused, so that precautions could be made in developing the performance measurement system. Based on the CFIs, companies in Thai automotive supply chains can support their decision making under scarce resources with valid data. A set of questionnaires with different performance attributes is used comprising of two separate parts, one intended for the first tier supplier companies and the other for the automakers. Each performance attribute in the questionnaires is assessed on how important the company sees them from their perspective, how well the tasks measured by each performance attribute have been carried out in their companies, how they see themselves compared to their competitors, and how they see each performance attribute developing compared to the situation 1 to 2 years before. The results provide a guideline to the companies in Thai automotive supply chains to measure the right performance attributes for making the right decision in a competitive environment.

Keywords: Supply chain performance, performance measurement, critical factor index, Thai automotive industry

INTRODUCTION

The Thai automotive industry is important to the Thai economy. It has been ranked one of the top ten of the Thai export products. Besides Thailand is a regional hub of automotives and auto-parts manufacturing of leading automakers in the world. To have low prices as a competitive advantage factor is no longer sufficient for surviving under this high competitive economy. For instance, during the 1980s there was the cheapest car, branded “Yugo”, sold

in the United States but it went out of business because of its poor quality and the customers did not want to buy this car at any price. Thus, the company using the cost strategy required to deliver the consistent quality to customers while still retaining an attractive margin between prices received from its customers and the amount it pays its suppliers. Similarly, this principle also applies to the company's suppliers. Effective supply chain management has become a key strategy for the industry to stay competitive. Performance measurement has thus become a crucial issue in automotive supply chain. With the scarce resources in highly competitive environment, the first step to improve supply chain performance is to know which supply chain's performance attributes are critical and should be improved.

LITERATURE REVIEW

The automotive supply chain in Thailand

Nowadays Thailand is a trusted regional automotive manufacturing hub of automotive leaders around the world. There are many automakers establish in Thailand (Automotive Intelligence Unit, 2010) such as Toyota Motor Thailand Co., Ltd., Isuzu Motors Company (Thailand) Co., Ltd., Honda Automobile (Thailand) Co., Ltd., Thai-Swedish Assembly Co., Ltd., General Motors (Thailand) Co., Ltd., Thonburi Automotive Assembly Plant Co., Ltd., Tata Motors (Thailand) Co., Ltd. (with manufacturing facility established at Thonburi Automotive Assembly Plant Co. Ltd.), Nissan Motor (Thailand) Co., Ltd., Nissan Diesel (Thailand) Co., Ltd., BMW Manufacturing (Thailand) Co., Ltd., Mitsubishi Fuso Truck (Thailand) Co., Ltd., Mitsubishi Motors (Thailand) Co., Ltd., Siam Motors And Nissan Co., Ltd., Auto Alliance (Thailand) Co., Ltd., Hino Motors Manufacturing (Thailand) Co., Ltd. etc. The Thai automotive supply chain involves many different industry sectors. The supply chain of Thai automotive industry is depicted in Figure 1.

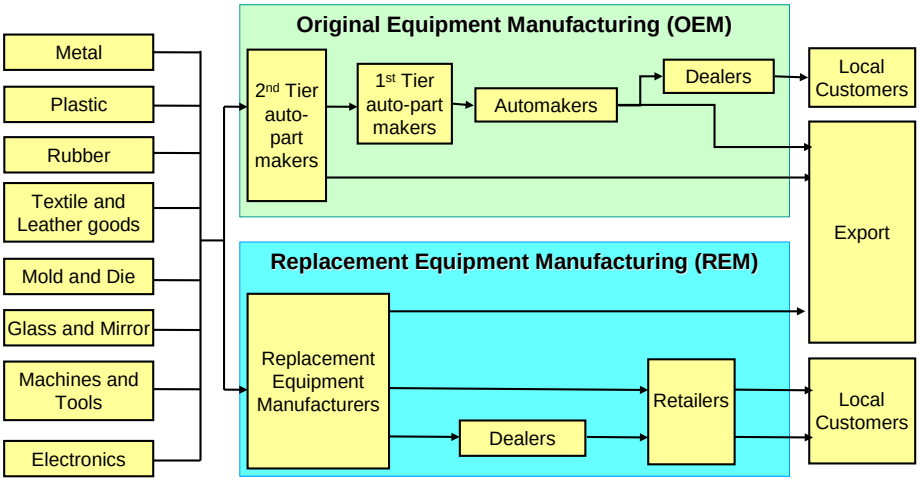

Figure 1: Thai automotive supply chain (adapted from NESDB, 2006).

As per National Economic and Social Development Board (2006), the generic Thai automotive supply chain comprises various industries from downstream to upstream (see

Figure 1). This ranges from the basic products such as metal, plastic, rubber, textile and leather goods, mold and die, electronics, etc. to the more complex products such as engine parts, body parts, lighting and electrical parts, transmission and steering parts, etc. The Thai automotive supply chain is separated into two groups, namely the Original Equipment Manufacturing (OEM) and Replacement Equipment Manufacturing (REM). This research is focused on the OEM side between first tier auto-part makers (or "first tier supplier" in this paper) and automakers.

Performance of the individual firm: Balanced scorecard

The balanced scorecard allows managers to look at the business from four important perspectives and could minimize information overload by limiting the number of measures used (Kaplan & Norton, 2005). Kaplan & Norton (2005) indicated that companies rarely suffer from having too few measures; on the contrary, they keep adding new measures whenever an employee or a consultant suggested. The balanced scorecard helped managers to focus on the handful of measures that are most critical, by forcing managers to consider all the important operational measures together, the balanced scorecard lets them see whether improvement in one area may have been achieved at the expense of another. The balanced scorecard translates a mission and strategy into a set of measures and metrics that comprises of four perspectives which link to performance measures. (Kaplan & Norton, 2005) Chareonsuk and Chansa-ngavej (2010) have studied the effect of intangible assets on the business performance of individual firm by adapting from the strategy map of balanced scorecard. They have explored the interrelationships of three elements of intangible assets: learning and growth, internal process, and external structure on the business performance of the firm.

Linkage for the firms in a supply chain: Trust

Nowadays several companies increase their competitive advantage by making the collaborative relationships with their alliance partners in the supply chain. Trust makes the supply chain relationships strong (Jones, Fawcett, Fawcett & Wallin, 2010; Robertson, 2006, p.81; Svensson, 2001). Benefits of trust to supply chains are as follows: (Jones, Fawcett, Fawcett & Wallin, 2010)

- Lower transaction costs to develop and maintain supply chain relationships by using fewer resources to develop detailed contracts; lower contract monitoring and enforcement costs; and reducing contract renewal, switching, and set up costs.
- Increased value-creation opportunities by identifying and sharing resources and knowledge to solve problems; jointly developing the product; and making process improvement
- Enhanced collaborative learning by having close collaboration allow information to flow freely among parties results in transfer of existing knowledge and generation of new knowledge.

Trust is a multidimensional concept (Jones, Fawcett, Fawcett & Wallin, 2010; Svensson, 2001) and the definitions of trust from several scholars are summarized (Jones, Fawcett, Fawcett and Wallin (2010) as per Table 1.

Table 1: Definitions of trust (Jones, Fawcett, Fawcett & Wallin, 2010).

Author(s)	Definition
Anderson and Narus (1990)	A firm's belief that another company will perform actions that will result in positive outcomes for the firm, as well as not take unexpected actions that would result in negative outcomes for the firm
Ring and Van de Ven (1992)	Confidence in the other's goodwill
Sabel (1993)	The mutual confidence that no party to an exchange will exploit the others' vulnerability
Mayer et al. (1995)	Willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party
Zaheer et al. (1998)	Expectation that an actor can be relied on to fulfill obligations, will behave in a predictable manner, and will act and negotiate fairly when the possibility of opportunism is present
Sako (1998)	Expectation held by an agent that its trading partner will behave in a mutually acceptable manner (including an expectation that neither party will exploit the other's vulnerabilities)
Dyer and Chu (2003)	One party's confidence that the other party in the exchange relationship will not exploit its vulnerabilities
Lui and Ngo (2004)	Expectation of a partner fulfilling a collaborative role in a risky situation, and (the reliability) of both the partner's intention to perform and its ability to do so
Kwon and Suh (2005)	A willingness to take risk and a willingness to rely on an exchange partner in whom one has confidence
Ireland and Webb (2007)	The decision to rely on a partner with the expectation that the partner will act according to a common agreement

Companies with supernormal returns (relational rent) are generated when partners make investment in relation-specific assets; exchange knowledge that results in joint learning; having join resources that create unique new products and services; and lower transaction costs because of effective governance mechanisms.

Fawcett et al. (2004) as cited in Jones et al (2010) developed a robust construct of trust that can be measured by categorizing trust to be five indicators as follows:

1. *Performance-to-promise*
   Trust are increase when the partners perform according to the promises they have made such as the buyers will gain more confidence in a supplier if the supplier repeatedly delivers product on time with consistent quality.
2. *Professional-relationship*
   The relationships occur from the buyer's agent and supplier's agent. The company's trustworthiness can be built if the company's agent demonstrates a consistent, credible, and positive interface with its partner's agent.
3. *Openness*
   Openness can be shown by the amount, frequency, and type of information sharing among supply chain partners. The openness can signal commitment to a relationship and increase trust because it makes visibility to the partners, then the uncertainty can be reduced.
4. *Benevolent-collaboration*
   Benevolent-collaboration can be in the form of resources planning. If supply chain partners share the saving they get, make some investments (such as in equipment, people etc.) to increase efficiency that benefit to their partner; then the supply chain partners will perceive one another as fair and can increase trust in each others.
5. *Empathy*

Supply chain partners that act with empathy will treat their partners fairly and consider their needs when making decisions. If the external environment changes such that their partner is in trouble, they may choose to alter its contract to safeguard the relationship.

RESEARCH FRAMEWORK

The purpose of the research is to gain insight into the relevant performance attributes that affect the automotive supply chains. The performance attributes were established according to each indicator for individual company. The companies in a supply chain can create more competitive advantage than individual company by making collaborative relationships with each other. Therefore, the benefits gained by two companies are more than sum of them. As mentioned in Jones, Fawcett, Fawcett and Wallin (2010), "trust" is the most essential elements to develop the strong collaborative relationships and the alliance parties in the supply chain could gain mutual benefit to achieve the competitive advantage. Hence, trust is an element that links the individual company in the supply chain and the level of trust can affect the performance of a supply chain.

According to the above reason, the individual company's elements (Chareonsuk & Chansa-ngavej, 2010), and the collaborative relationships element or "trust" (Jones, Fawcett, Fawcett & Wallin, 2010) with their indicators were used as a basis to established the elements of supply chain performance and their indicators. The elements of supply chain performance and their indicators are depicted in Table 2. The Thai automotive supply chain was used as a case study for finding the critical performance attributes of the first tier suppliers and automakers.

Table 2: The elements of supply chain performance and their indicators.

Elements of Supply Chain Performance	Supply Chain Performance Indicators
Business performance	Financial Sales Customer
External structure	Customer satisfaction Customer loyalty Brand
Internal process	Process improvement Innovation Information technology
Learning and growth	Know-how Knowledge Competency Engagement
Trust	Performance-to-promise Professional-relationship Openness Benevolent-collaboration Empathy

RESEARCH METHODOLOGY

Planning the questionnaire

The primary data for analyzing and investigating the critical performance attributes were gathered by opinion survey questionnaire. The population was limited to the companies within the automotive industry in Thailand. Two questionnaires were developed. The performance attributes in the questionnaires are based on the research performed by Chareonsuk and Chansa-ngavej (2010) and Jones et al. (2010) that were categorized under five main elements: business performance, internal structure, external structure, learning and growth, and trust. A set of questionnaires comprising of two separate parts; one intended for the first tier supplier companies, i.e. companies that produce materials and components for car manufacturers; and the other for the automaker companies, i.e. automotive assemblers. The list of the target group is gathered from the database of Automotive Intelligent Unit, Thailand Automotive Institute (TAI). The questionnaires were mailed to the top management, factory managers, sales managers, and purchasing managers of first tier suppliers and automakers in the Thai automotive supply chains.

Each performance attribute in the questionnaires is assessed on how important the company sees them from their perspective, how well the tasks measured by each performance attribute have been carried out in their companies, how they see themselves compared to their competitors and how they see each performance attribute developing compared to the situation 1 to 2 years before. The format of the questionnaire had been adapted from Ranta and Takala (2007) and shown in Figure 2. The questionnaire format can be used to collect answers that reliable and valid ones, the structure is attractive to answer and the wide numerical estimation- scale from 1 to 10 made the questionnaire to be easy to find differences between attributes (Ranta & Takala, 2007).

Performance Attribute	Scale: 1 = Low, 10 = High		Compared with competitors			Direction of development		
	Expectation (1-10)	Experiences (1-10)	Worse	Same	Better	Worse	Same	Better
Performance Attribute#1			☐	☐	☐	☐	☐	☐
Performance Attribute#2			☐	☐	☐	☐	☐	☐

Figure 2: Format of the questionnaire (adapted from Ranta and Takala 2007).

RESULTS

Data analysis

A total of 14 questionnaires from 1st tier suppliers were completed. In order to compare the views and opinions of the different interest groups, the respondents were divided into 4 groups: Top management, Factory managers, Purchasing managers and Sales/Marketing managers. The purchasing manager group was excluded from the analysis since only one respondent answered which could not be analyzed by using one respondent. Then, the averages and standard deviations of the expectations and experiences for each performance

attributes are calculated. Standard deviations help to evaluate the validity and reliability of the results. Gap index is calculated from the absolute value of the expectations and experiences. The direction of development and importance index are calculated by using the formulas shown in Figure 3.

The value of each index can be interpreted as shown in Table 2.

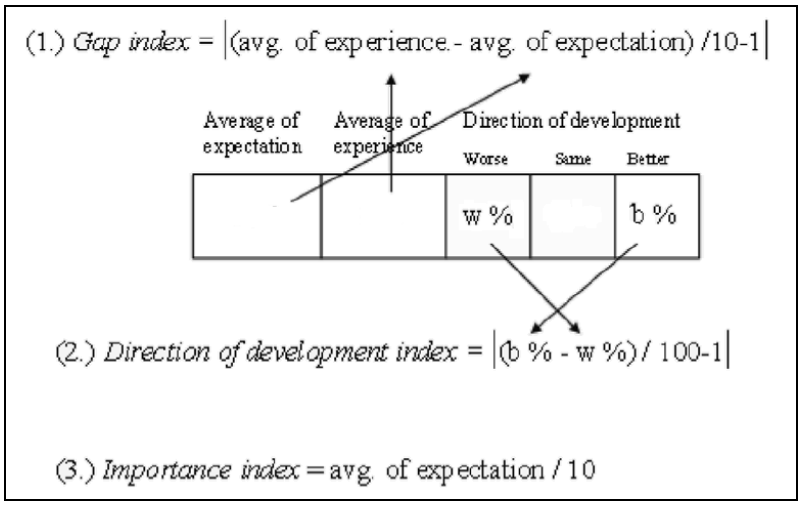

Figure 3: Calculating formulas (Ranta and Takala, 2007).

Table 2: Meaning of each indexes (Ranta and Takala, 2007).

Index	Value	Meaning
Direction of development	= 1	The performance has remained on the same level.
	< 1	The performance has been developed.
	> 1	The performance has been decreased.
Gap index	= 1	There is no gap between expectations and experiences.
	< 1	The expectations are lower than experiences.
	> 1	The experiences are lower than expectations
Importance index	Large	More important expectation of the attribute.
	Small	Less important expectation of the attribute.

The results of standard deviations and indexes are used to calculate Critical Factor Index (CFI) in order to determine whether which performance attributes are considered to be strength and which ones need to be specially focused. The equation of CFI is depicted in Figure 4. The smaller value of the CFI is more critical performance attribute.

$$\text{CFI} = \frac{\text{SD of expectation} * \text{SD of experience}}{\text{Importance index} * \text{Gap index} * \text{Direction of development index}}$$

Figure 4: Critical Factor Index (CFI) (Ranta and Takala, 2007).

Research results

The analysis was done by including all the answers and separating each group of respondents i.e. Top management, Factory manager, and Sales/Marketing manager. The

reason to separate these groups is to see the critical performance attributes from different perspectives. The top management group looks at the performance attributes in the strategic view. The factory manager group looks at the performance attributes in the operation or practical point of view. The sales/marketing manager group considers the performance attribute as a joint that is closest to the automotive customer.

Preliminary analysis – All

The preliminary result for answer collected from all 13 respondents of 1st tier suppliers is depicted in Table 3.

Table 3: Preliminary result for answer collected from all 1st tier suppliers.

Performance Attribute		*Expectations*		*Experiences*		*Compared with competitors*			*Direction of development*		
		Average	*SD*	*Average*	*SD*	*Worse %*	*Same %*	*Better %*	*Worse %*	*Same %*	*Better %*
1	LKH1	8.46	1.27	6.23	1.96	30.77%	30.77%	38.46%	7.69%	46.15%	46.15%
2	LKH2	8.38	1.94	6.23	1.69	15.38%	53.85%	30.77%	7.69%	53.85%	38.46%
3	LKH3	8.31	1.80	7.00	1.58	7.69%	53.85%	38.46%	0.00%	53.85%	46.15%
4	LKH4	8.77	2.28	7.00	2.48	15.38%	38.46%	46.15%	15.38%	38.46%	46.15%
5	LKH5	7.92	1.89	6.15	2.61	15.38%	69.23%	15.38%	**23.08%**	53.85%	**23.08%**
6	LKL1	8.38	1.76	5.77	1.83	**23.08%**	69.23%	7.69%	0.00%	76.92%	23.08%
7	LKL2	8.31	1.70	6.08	1.61	15.38%	38.46%	46.15%	0.00%	53.85%	46.15%
8	LKL3	8.38	1.50	6.46	2.07	7.69%	61.54%	30.77%	0.00%	46.15%	53.85%
9	LKL4	9.23	1.30	7.46	1.98	0.00%	46.15%	53.85%	7.69%	46.15%	46.15%
10	LKL5	8.23	1.42	5.15	1.77	**38.46%**	53.85%	7.69%	**15.38%**	69.23%	**15.38%**
11	LC1	8.85	1.21	6.46	1.51	23.08%	23.08%	53.85%	0.00%	53.85%	46.15%
12	LC2	7.77	2.09	5.69	2.06	0.00%	84.62%	15.38%	0.00%	76.92%	23.08%
13	LC3	8.31	1.70	5.46	2.30	15.38%	69.23%	15.38%	0.00%	69.23%	30.77%
14	LC4	9.08	1.32	6.38	1.33	0.00%	53.85%	46.15%	0.00%	69.23%	30.77%
15	LC5	8.31	1.44	6.08	1.98	15.38%	61.54%	23.08%	7.69%	61.54%	30.77%
16	LE1	7.62	1.80	5.62	1.98	15.38%	53.85%	30.77%	0.00%	61.54%	38.46%
17	LE2	8.08	1.75	5.92	2.47	**30.77%**	46.15%	23.08%	0.00%	84.62%	15.38%
18	LE3	7.69	2.36	**5.00**	2.31	**15.38%**	84.62%	0.00%	**15.38%**	76.92%	7.69%
19	LE4	9.23	1.01	7.23	**0.73**	0.00%	53.85%	46.15%	0.00%	53.85%	46.15%
20	LE5	8.62	1.19	6.77	2.05	7.69%	30.77%	61.54%	7.69%	46.15%	46.15%
21	TPP1	8.54	1.94	7.46	2.15	15.38%	30.77%	53.85%	7.69%	30.77%	61.54%
22	TPP2	9.46	0.78	8.77	1.30	7.69%	38.46%	53.85%	0.00%	38.46%	61.54%
23	TPP3	9.31	1.49	**8.85**	1.57	0.00%	46.15%	53.85%	0.00%	38.46%	61.54%
24	TPR1	9.08	1.44	8.54	1.76	0.00%	38.46%	61.54%	0.00%	46.15%	53.85%
25	TPR2	9.15	1.28	8.62	1.33	0.00%	30.77%	69.23%	0.00%	53.85%	46.15%
26	TPR3	**9.85**	**0.38**	**9.15**	**0.90**	0.00%	46.15%	53.85%	0.00%	38.46%	61.54%
27	TO1	9.38	1.19	**9.08**	1.32	0.00%	46.15%	53.85%	0.00%	38.46%	61.54%
28	TO2	9.54	0.78	8.62	1.71	0.00%	53.85%	46.15%	0.00%	46.15%	53.85%
29	TO3	9.00	1.53	8.38	2.06	0.00%	46.15%	53.85%	0.00%	46.15%	53.85%
30	TO4	9.23	1.30	7.54	1.76	0.00%	46.15%	53.85%	0.00%	30.77%	69.23%
31	TO5	7.54	2.33	6.08	2.43	7.69%	69.23%	23.08%	0.00%	76.92%	23.08%
32	TBC1	8.62	1.56	7.54	1.85	0.00%	69.23%	30.77%	0.00%	53.85%	46.15%
33	TBC2	7.77	2.13	6.85	2.44	0.00%	76.92%	23.08%	0.00%	61.54%	38.46%
34	TBC3	8.15	1.82	7.46	2.22	0.00%	61.54%	38.46%	0.00%	53.85%	46.15%
35	TBC4	**6.77**	2.45	5.46	2.57	**15.38%**	69.23%	**15.38%**	0.00%	61.54%	38.46%
36	TBC5	**6.92**	**2.81**	5.54	3.07	7.69%	69.23%	23.08%	0.00%	69.23%	30.77%
37	TE1	7.62	2.18	6.69	2.10	0.00%	76.92%	23.08%	0.00%	76.92%	23.08%
38	TE2	8.31	2.43	7.92	2.18	0.00%	53.85%	46.15%	0.00%	61.54%	38.46%
39	TE3	7.38	2.50	6.54	2.37	0.00%	61.54%	38.46%	0.00%	61.54%	38.46%
40	TE4	8.38	2.22	7.62	2.43	0.00%	46.15%	53.85%	0.00%	61.54%	38.46%
41	IPI1	9.08	1.12	7.46	2.07	0.00%	23.08%	76.92%	0.00%	23.08%	76.92%
42	IPI2	9.00	1.29	7.31	1.75	7.69%	30.77%	61.54%	0.00%	38.46%	61.54%

43	IPI3	9.31	1.11	7.69	1.89	15.38%	46.15%	38.46%	7.69%	46.15%	46.15%
44	IPI4	8.92	1.32	6.92	1.80	0.00%	76.92%	23.08%	0.00%	61.54%	38.46%
45	IPI5	8.46	1.81	6.62	1.89	23.08%	46.15%	30.77%	15.38%	30.77%	53.85%
46	IPI6	8.85	1.57	7.62	1.76	7.69%	53.85%	38.46%	0.00%	46.15%	53.85%
47	II1	8.46	1.56	7.62	1.94	0.00%	46.15%	53.85%	0.00%	53.85%	46.15%
48	II2	8.46	1.66	6.85	1.63	15.38%	38.46%	46.15%	7.69%	46.15%	46.15%
49	II3	8.46	1.90	6.54	2.11	15.38%	38.46%	46.15%	0.00%	46.15%	53.85%
50	II4	8.23	1.92	6.15	2.12	23.08%	46.15%	30.77%	7.69%	46.15%	46.15%
51	II5	7.77	1.92	**5.00**	1.68	**23.08%**	69.23%	7.69%	7.69%	53.85%	38.46%
52	IIT1	8.46	1.27	6.85	1.95	7.69%	46.15%	46.15%	0.00%	38.46%	61.54%
53	IIT2	8.77	1.54	6.69	1.60	15.38%	53.85%	30.77%	0.00%	46.15%	53.85%
54	IIT3	8.54	1.71	7.23	1.96	0.00%	69.23%	30.77%	0.00%	46.15%	53.85%
55	IIT4	**6.31**	2.56	**2.69**	2.02	**46.15%**	53.85%	0.00%	7.69%	69.23%	23.08%
56	IIT5	9.00	1.29	7.15	1.46	7.69%	53.85%	38.46%	0.00%	53.85%	46.15%
57	ECS1	9.00	1.08	7.38	1.71	0.00%	84.62%	15.38%	0.00%	61.54%	38.46%
58	ECS2	8.77	1.79	7.23	2.01	7.69%	61.54%	30.77%	0.00%	53.85%	46.15%
59	ECS3	8.69	1.25	7.54	1.71	0.00%	53.85%	46.15%	0.00%	46.15%	53.85%
60	ECS4	9.00	1.08	7.62	1.04	0.00%	61.54%	38.46%	0.00%	46.15%	53.85%
61	ECS5	9.08	1.55	7.54	2.03	7.69%	53.85%	38.46%	7.69%	38.46%	53.85%
62	ECS6	8.85	1.46	7.46	1.66	0.00%	61.54%	38.46%	0.00%	61.54%	38.46%
63	ECS7	9.15	1.14	7.69	1.38	0.00%	46.15%	53.85%	7.69%	38.46%	53.85%
64	ECL1	8.54	1.13	7.31	1.70	0.00%	69.23%	30.77%	0.00%	46.15%	53.85%
65	ECL2	7.85	1.57	6.77	1.74	0.00%	84.62%	15.38%	0.00%	61.54%	38.46%
66	ECL3	8.62	1.80	7.77	1.92	7.69%	61.54%	30.77%	0.00%	46.15%	53.85%
67	ECL4	8.15	1.72	7.23	2.13	0.00%	61.54%	38.46%	0.00%	61.54%	38.46%
68	EB1	8.38	1.76	6.62	2.02	7.69%	61.54%	30.77%	0.00%	69.23%	30.77%
69	EB2	7.77	1.92	6.85	1.82	7.69%	61.54%	30.77%	0.00%	53.85%	46.15%
70	EB3	8.85	1.21	7.77	1.59	7.69%	53.85%	38.46%	0.00%	53.85%	46.15%
71	EB4	7.54	2.22	5.69	2.43	23.08%	53.85%	23.08%	0.00%	69.23%	30.77%
72	EB5	7.54	2.15	5.23	2.31	15.38%	46.15%	38.46%	0.00%	53.85%	46.15%
73	EB6	7.85	2.58	6.31	2.36	7.69%	53.85%	38.46%	0.00%	61.54%	38.46%
74	BF1	8.92	2.72	6.31	**3.22**	23.08%	38.46%	23.08%	15.38%	30.77%	46.15%
75	BF2	8.62	**2.84**	6.31	**3.12**	15.38%	46.15%	23.08%	23.08%	23.08%	46.15%
76	BF3	8.92	2.72	6.31	**3.25**	23.08%	38.46%	23.08%	23.08%	23.08%	46.15%
77	BS1	8.62	2.72	7.23	2.59	23.08%	46.15%	23.08%	0.00%	46.15%	46.15%
78	BS2	8.62	2.75	6.85	2.70	15.38%	53.85%	23.08%	7.69%	30.77%	53.85%
79	BS3	8.23	2.80	6.08	2.90	**30.77%**	38.46%	23.08%	7.69%	46.15%	38.46%
80	BS4	8.38	**2.84**	6.23	2.89	15.38%	38.46%	38.46%	7.69%	30.77%	53.85%
81	BC1	**9.77**	**0.60**	8.08	**0.76**	0.00%	38.46%	61.54%	0.00%	46.15%	53.85%
82	BC2	9.62	0.77	8.31	1.25	0.00%	61.54%	38.46%	7.69%	53.85%	38.46%
83	BC3	8.77	1.64	7.08	2.75	23.08%	38.46%	38.46%	7.69%	30.77%	61.54%
84	BC4	8.08	1.80	6.69	2.10	0.00%	69.23%	30.77%	0.00%	53.85%	46.15%
85	BC5	7.92	1.71	6.54	2.18	7.69%	69.23%	23.08%	0.00%	61.54%	38.46%
86	BC6	9.62	0.77	8.38	1.26	7.69%	69.23%	23.08%	0.00%	61.54%	38.46%
87	BC7	8.38	2.63	7.85	2.48	0.00%	38.46%	61.54%	0.00%	46.15%	53.85%
88	BC8	**9.69**	**0.63**	8.38	0.96	0.00%	46.15%	53.85%	0.00%	61.54%	38.46%

Preliminary result indicates the high expectation on TPR3, BC1, and BC8 which are honest and truthful with customers; customer satisfaction; and overall response to customer. The performance attribute of TPR3 (honest and truthful with customers) also has high value in how the companies see that the performance attribute is being carried out in their companies (experience). The lowest importance for companies are IIT4, TBC4, and TBC5 which are completing the registration of new ideas and products at the Department of Intellectual Property; offering technical training/education to customers to help them improve performance; and sharing profits gained through collaborative efforts with their customers. The IIT4 (completing the registration of new ideas and products at Department of Intellectual Property) also has lowest value in how performance attributes are being fulfilled in the companies (experience).

All the performance attributes have the score higher in importance than the experience in their companies. This features show that all the performance attributes should be developed. However, there are a total of 88 performance attributes and the companies have the scarce resources. Therefore, they have to find and focus on the critical performance attributes determined in this paper by using CFI. The respondents see that nearly all performance attributes in their companies are better than competitors, except 7 out of 88 performance attributes that are worse than their competitors. These seven performance attributes are LKL1 (comprehensive in recruitment program by dedicating to hiring the best candidates available), LKL5 (provision of self-learning facilities for employees), LE2 (The employees generally give their all which makes the firm different from the others in the industry), LE3 (Employee involvement in business policy and strategy setting), II5 (Development of new ideas and products), IIT4 (Registration of new ideas and products at the Department of Intellectual Property), and BS3 (Market share). There is one performance attribute that is the same as their competitors, which is TBC4 (Technical training/education that offered to customers to help them improve performance). This may be because they see the TBC4 as low in important as the average of expectation is only 6.77. Normally in the Thai automotive supply chain, most of the automakers are huge multinational companies that transfer knowledge to them.

All the performance attributes at the time the respondents answer in the questionnaires are better than last two years, except LE3 (The employee involvement in business policy and strategy setting), which is worse than previous; and LKH5 (A succession training program for replacement an employee who leaved the firm) and LKL5 (Provision of self-learning facilities for employees) are remaining the same as previous two years.
In the next sections, the answers were divided into three separated groups of positions, namely Top management, Factory managers, and Sales/Marketing managers.

Preliminary analysis – Top management

The preliminary answers from top management of 1st tier suppliers are depicted in Table 4.

Table 4: Preliminary result for answer collected from Top management of 1st tier suppliers.

	Performance Attribute	*Expectations*		*Experiences*		*Compared with competitors*			*Direction of development*		
		Average	*SD*	*Average*	*SD*	*Worse %*	*Same %*	*Better %*	*Worse %*	*Same %*	*Better %*
1	LKH1	9.00	1.41	6.60	2.30	20.00%	40.00%	40.00%	0.00%	60.00%	40.00%
2	LKH2	8.80	1.79	6.60	2.07	0.00%	40.00%	60.00%	0.00%	20.00%	80.00%
3	LKH3	8.40	1.82	7.40	1.95	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
4	LKH4	7.60	3.36	7.00	3.24	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
5	LKH5	8.20	2.49	6.60	2.61	0.00%	80.00%	20.00%	0.00%	80.00%	20.00%
6	LKL1	9.00	1.41	5.80	2.17	**20.00%**	80.00%	0.00%	0.00%	80.00%	20.00%
7	LKL2	9.40	**0.89**	6.80	1.30	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
8	LKL3	8.40	1.52	7.20	2.28	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%
9	LKL4	8.80	1.79	7.60	2.51	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
10	LKL5	8.80	1.30	5.40	2.07	**20.00%**	80.00%	0.00%	**0.00%**	100.00%	**0.00%**
11	LC1	9.00	1.41	7.20	1.30	20.00%	20.00%	60.00%	0.00%	60.00%	40.00%
12	LC2	8.40	1.82	5.40	1.82	0.00%	80.00%	20.00%	0.00%	60.00%	40.00%
13	LC3	8.60	1.34	5.80	**0.84**	**0.00%**	100.00%	**0.00%**	0.00%	60.00%	40.00%
14	LC4	8.60	1.52	6.00	1.58	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%
15	LC5	8.40	1.67	6.80	2.17	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%

16	LE1	8.20	2.05	6.60	2.30	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
17	LE2	8.20	1.79	6.40	2.07	**20.00%**	60.00%	**20.00%**	0.00%	80.00%	20.00%
18	LE3	7.40	2.79	5.20	2.39	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
19	LE4	8.80	1.10	7.20	**0.84**	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%
20	LE5	8.40	1.52	6.40	2.30	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
21	TPP1	7.80	2.86	7.20	2.68	0.00%	20.00%	80.00%	0.00%	40.00%	60.00%
22	TPP2	9.00	1.00	8.40	1.52	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
23	TPP3	8.60	2.19	8.20	2.05	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
24	TPR1	8.00	1.87	7.60	2.30	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
25	TPR2	8.20	1.64	7.80	1.64	0.00%	20.00%	80.00%	0.00%	40.00%	60.00%
26	TPR3	**9.80**	**0.45**	**9.00**	1.00	0.00%	20.00%	80.00%	0.00%	40.00%	60.00%
27	TO1	9.00	1.73	**8.60**	1.67	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
28	TO2	9.60	**0.89**	7.80	2.17	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
29	TO3	8.40	2.30	7.40	2.97	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
30	TO4	9.20	1.79	6.80	2.39	0.00%	40.00%	60.00%	0.00%	20.00%	80.00%
31	TO5	6.80	3.11	**4.80**	3.11	**20.00%**	60.00%	**20.00%**	0.00%	80.00%	20.00%
32	TBC1	8.00	2.12	7.00	2.12	0.00%	80.00%	20.00%	0.00%	80.00%	20.00%
33	TBC2	7.20	2.68	5.40	2.88	0.00%	80.00%	20.00%	0.00%	80.00%	20.00%
34	TBC3	7.40	2.51	6.60	3.13	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
35	TBC4	**6.60**	3.44	5.20	2.95	**20.00%**	60.00%	**20.00%**	0.00%	40.00%	60.00%
36	TBC5	**6.00**	3.81	5.40	3.58	0.00%	80.00%	20.00%	0.00%	80.00%	20.00%
37	TE1	6.80	2.39	5.60	2.30	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%
38	TE2	7.40	3.29	6.60	2.30	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%
39	TE3	7.00	3.08	5.40	2.88	0.00%	60.00%	40.00%	0.00%	80.00%	20.00%
40	TE4	7.20	3.27	6.80	3.42	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
41	IPI1	8.80	1.10	7.60	1.34	0.00%	20.00%	80.00%	0.00%	20.00%	80.00%
42	IPI2	9.00	1.73	7.00	1.87	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
43	IPI3	8.80	1.64	8.00	2.12	20.00%	40.00%	40.00%	0.00%	40.00%	60.00%
44	IPI4	8.40	1.52	6.20	2.17	0.00%	80.00%	20.00%	0.00%	60.00%	40.00%
45	IPI5	8.20	2.49	6.60	1.34	**20.00%**	60.00%	**20.00%**	20.00%	20.00%	60.00%
46	IPI6	8.60	2.19	8.20	1.92	20.00%	20.00%	60.00%	0.00%	20.00%	80.00%
47	II1	8.60	1.34	7.60	2.30	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
48	II2	8.20	1.79	7.00	1.58	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
49	II3	7.80	2.17	6.00	2.35	20.00%	40.00%	40.00%	0.00%	40.00%	60.00%
50	II4	7.60	2.30	6.20	2.68	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
51	II5	7.40	2.41	**4.80**	1.48	**20.00%**	80.00%	0.00%	0.00%	60.00%	40.00%
52	IIT1	8.60	1.52	6.20	2.17	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
53	IIT2	8.40	2.30	6.80	1.64	20.00%	40.00%	40.00%	0.00%	40.00%	60.00%
54	IIT3	7.80	2.28	6.60	2.70	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
55	IIT4	**6.20**	2.59	**3.40**	1.82	**60.00%**	40.00%	0.00%	0.00%	60.00%	40.00%
56	IIT5	9.60	**0.89**	7.00	2.12	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
57	ECS1	8.60	1.34	6.60	2.07	0.00%	80.00%	20.00%	0.00%	80.00%	20.00%
58	ECS2	8.20	2.68	7.40	2.79	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
59	ECS3	8.40	1.67	7.60	2.30	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
60	ECS4	9.20	1.10	7.60	1.67	0.00%	40.00%	60.00%	0.00%	20.00%	80.00%
61	ECS5	9.40	1.34	8.00	1.87	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
62	ECS6	8.40	1.82	6.60	2.07	0.00%	80.00%	20.00%	0.00%	60.00%	40.00%
63	ECS7	9.60	**0.89**	8.20	1.10	0.00%	40.00%	60.00%	20.00%	20.00%	60.00%
64	ECL1	8.60	1.34	7.20	1.92	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
65	ECL2	8.20	1.64	6.20	2.17	0.00%	80.00%	20.00%	0.00%	60.00%	40.00%
66	ECL3	8.40	2.07	7.40	2.41	20.00%	40.00%	40.00%	0.00%	40.00%	60.00%
67	ECL4	8.00	2.00	6.40	2.19	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
68	EB1	7.60	2.30	6.20	2.17	0.00%	80.00%	20.00%	0.00%	60.00%	40.00%
69	EB2	8.20	2.17	7.20	2.28	0.00%	40.00%	60.00%	0.00%	20.00%	80.00%
70	EB3	9.00	1.41	8.00	2.00	0.00%	40.00%	60.00%	0.00%	20.00%	80.00%
71	EB4	7.60	2.30	5.20	2.77	**20.00%**	60.00%	**20.00%**	0.00%	60.00%	40.00%
72	EB5	8.00	2.12	6.00	2.35	20.00%	40.00%	40.00%	0.00%	40.00%	60.00%
73	EB6	8.60	1.52	7.80	2.17	0.00%	40.00%	60.00%	0.00%	40.00%	60.00%
74	BF1	8.00	**4.47**	7.00	**4.12**	0.00%	20.00%	40.00%	0.00%	40.00%	40.00%
75	BF2	7.20	4.38	6.00	3.94	0.00%	40.00%	20.00%	20.00%	20.00%	40.00%
76	BF3	8.00	**4.47**	6.40	**4.10**	0.00%	40.00%	20.00%	20.00%	20.00%	40.00%
77	BS1	7.60	4.34	6.60	**4.10**	0.00%	40.00%	40.00%	0.00%	40.00%	40.00%
78	BS2	7.60	4.34	6.20	3.90	0.00%	40.00%	40.00%	0.00%	40.00%	40.00%

79	BS3	7.60	4.34	6.20	3.90	0.00%	40.00%	40.00%	0.00%	40.00%	40.00%
80	BS4	8.00	**4.47**	6.20	3.90	0.00%	20.00%	60.00%	0.00%	20.00%	60.00%
81	BC1	9.60	**0.89**	8.20	**0.84**	0.00%	20.00%	80.00%	0.00%	40.00%	60.00%
82	BC2	9.60	**0.89**	8.20	1.30	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
83	BC3	8.60	2.19	7.00	2.55	40.00%	0.00%	60.00%	0.00%	20.00%	80.00%
84	BC4	7.80	2.28	6.80	2.59	0.00%	60.00%	40.00%	0.00%	40.00%	60.00%
85	BC5	8.00	2.00	6.60	2.30	0.00%	60.00%	40.00%	0.00%	60.00%	40.00%
86	BC6	9.60	**0.89**	**8.60**	1.34	20.00%	40.00%	40.00%	0.00%	60.00%	40.00%
87	BC7	7.80	3.90	7.00	2.83	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%
88	BC8	9.60	**0.89**	8.40	0.89	0.00%	40.00%	60.00%	0.00%	60.00%	40.00%

The top management sees TPR3 (honest and truthful with customers) as the highest importance and the experience of this performance attribute being carried out in the companies is also high. This is the same as the result from all positions. In the top management's point of view, the lowest importance for companies are the same as results from all positions which are TBC5, IIT4, and TBC4 which are sharing profits gained through collaborative efforts with their customers; completing the registration of new ideas and products at Department of Intellectual Property; and offering technical training/education to customers to help them improve performance. The IIT4 (completing the registration of new ideas and products at Department of Intellectual Property) is also has lowest value in how performance attributes are being carried out in the companies. This is also the same as the result from all position. This may be because most of the 1st tier suppliers of the Thai automotive companies are the OEM (Original Equipment Manufacturing). Almost all of the auto parts are designed by the customers (automakers) or otherwise the collaborative design is made by involving part makers at the beginning stage of product development. There are only a few 1st tier suppliers that have their own designed products and offer for use in the automobiles. The top management sees that all performance attributes are better than last two years as depicted in the direction of development, except LKL5 (provision of self-learning facilities for employees) and LE3 (employee involvement in business policy and strategy setting) are the same as previous two years.

Preliminary analysis – Factory manager

The preliminary answers from factory managers of 1st tier suppliers are shown in Table 5.

Table 5: Preliminary result for answer collected from Factory Manager of 1st tier suppliers.

Performance Attribute		*Expectations*		*Experiences*		*Compared with competitors*			*Direction of development*		
		Average	*SD*	*Average*	*SD*	*Worse %*	*Same %*	*Better %*	*Worse %*	*Same %*	*Better %*
1	LKH1	8.25	1.50	5.25	2.50	25.00%	0.00%	75.00%	0.00%	25.00%	75.00%
2	LKH2	8.50	**2.38**	5.50	1.73	**25.00%**	50.00%	**25.00%**	0.00%	75.00%	25.00%
3	LKH3	9.00	1.15	6.75	1.71	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
4	LKH4	9.50	1.00	7.50	1.29	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
5	LKH5	8.00	2.16	6.00	**3.16**	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
6	LKL1	8.25	2.22	5.50	2.52	**50.00%**	25.00%	25.00%	0.00%	50.00%	50.00%
7	LKL2	8.25	2.36	5.00	1.83	**50.00%**	0.00%	**50.00%**	0.00%	50.00%	50.00%
8	LKL3	8.25	2.06	5.75	2.06	0.00%	75.00%	25.00%	0.00%	0.00%	100.00%
9	LKL4	9.50	1.00	7.25	1.71	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
10	LKL5	8.00	2.16	4.50	1.73	**25.00%**	50.00%	**25.00%**	0.00%	50.00%	50.00%
11	LC1	9.25	0.96	5.50	1.91	25.00%	25.00%	50.00%	0.00%	0.00%	100.00%
12	LC2	8.00	**2.45**	5.00	2.45	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
13	LC3	7.75	**2.63**	**3.25**	2.06	**25.00%**	50.00%	**25.00%**	0.00%	75.00%	25.00%
14	LC4	9.25	1.50	6.25	0.96	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%

15	LC5	8.75	1.89	5.50	1.73	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
16	LE1	6.75	2.36	3.75	0.96	25.00%	25.00%	50.00%	0.00%	25.00%	75.00%
17	LE2	8.25	2.36	3.75	2.06	50.00%	50.00%	0.00%	0.00%	100.00%	0.00%
18	LE3	6.50	2.38	3.50	1.73	25.00%	75.00%	0.00%	25.00%	50.00%	25.00%
19	LE4	9.50	1.00	7.25	0.50	0.00%	50.00%	50.00%	0.00%	0.00%	100.00%
20	LE5	9.00	0.82	7.25	1.26	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
21	TPP1	8.50	1.00	7.00	1.41	25.00%	50.00%	25.00%	0.00%	0.00%	100.00%
22	TPP2	9.75	0.50	8.50	1.29	25.00%	25.00%	50.00%	0.00%	0.00%	100.00%
23	TPP3	9.50	1.00	8.50	1.29	0.00%	50.00%	50.00%	0.00%	0.00%	100.00%
24	TPR1	9.50	0.58	8.50	1.29	0.00%	25.00%	75.00%	0.00%	0.00%	100.00%
25	TPR2	9.75	0.50	8.75	0.96	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
26	TPR3	9.75	0.50	9.25	0.96	0.00%	50.00%	50.00%	0.00%	0.00%	100.00%
27	TO1	9.25	0.96	9.00	1.41	0.00%	50.00%	50.00%	0.00%	0.00%	100.00%
28	TO2	9.50	0.58	9.00	1.15	0.00%	25.00%	75.00%	0.00%	0.00%	100.00%
29	TO3	9.50	0.58	9.00	1.15	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
30	TO4	9.50	0.58	7.75	0.96	0.00%	25.00%	75.00%	0.00%	0.00%	100.00%
31	TO5	8.25	1.71	7.50	2.08	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
32	TBC1	9.50	0.58	8.50	1.29	0.00%	50.00%	50.00%	0.00%	0.00%	100.00%
33	TBC2	9.00	1.15	8.25	1.50	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
34	TBC3	9.00	1.15	8.00	1.41	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
35	TBC4	7.25	2.22	5.50	3.70	25.00%	50.00%	25.00%	0.00%	50.00%	50.00%
36	TBC5	7.50	2.38	5.00	2.16	25.00%	50.00%	25.00%	0.00%	50.00%	50.00%
37	TE1	9.25	0.50	8.00	0.82	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
38	TE2	9.25	0.96	9.25	0.96	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
39	TE3	9.25	0.96	8.25	1.26	0.00%	25.00%	75.00%	0.00%	0.00%	100.00%
40	TE4	9.50	0.58	8.25	1.26	0.00%	25.00%	75.00%	0.00%	50.00%	50.00%
41	IPI1	9.25	0.96	7.75	1.71	0.00%	25.00%	75.00%	0.00%	0.00%	100.00%
42	IPI2	9.25	0.96	7.75	1.71	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
43	IPI3	9.50	0.58	7.75	0.96	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
44	IPI4	9.75	0.50	8.25	1.50	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
45	IPI5	9.00	1.15	6.75	2.22	25.00%	25.00%	50.00%	0.00%	25.00%	75.00%
46	IPI6	9.00	1.15	6.50	1.73	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
47	II1	9.00	1.15	8.00	1.83	0.00%	0.00%	100.00%	0.00%	25.00%	75.00%
48	II2	9.25	0.96	6.75	1.26	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
49	II3	9.50	0.58	7.00	1.41	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
50	II4	9.25	0.96	6.25	1.50	25.00%	25.00%	50.00%	0.00%	25.00%	75.00%
51	II5	8.75	1.50	5.75	1.71	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
52	IIT1	8.75	1.50	7.50	2.08	25.00%	25.00%	50.00%	0.00%	0.00%	100.00%
53	IIT2	9.25	0.96	6.50	1.73	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
54	IIT3	9.25	0.96	7.50	1.29	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
55	IIT4	7.50	2.08	2.50	2.38	0.00%	100.00%	0.00%	0.00%	75.00%	25.00%
56	IIT5	9.75	0.50	7.50	0.58	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
57	ECS1	9.75	0.50	8.25	0.96	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
58	ECS2	9.25	0.96	6.75	0.96	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
59	ECS3	9.50	1.00	7.75	0.50	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
60	ECS4	9.75	0.50	7.75	0.50	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
61	ECS5	9.75	0.50	8.00	0.82	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
62	ECS6	9.50	1.00	8.50	1.29	0.00%	25.00%	75.00%	0.00%	50.00%	50.00%
63	ECS7	9.00	1.15	7.00	1.41	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
64	ECL1	8.50	1.29	7.25	1.89	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
65	ECL2	8.25	1.71	7.00	1.41	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
66	ECL3	9.50	1.00	8.50	1.29	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
67	ECL4	9.50	0.58	8.50	1.91	0.00%	25.00%	75.00%	0.00%	50.00%	50.00%
68	EB1	8.75	1.50	6.75	1.71	25.00%	50.00%	25.00%	0.00%	50.00%	50.00%
69	EB2	8.00	2.16	7.00	1.83	25.00%	50.00%	25.00%	0.00%	50.00%	50.00%
70	EB3	9.50	1.00	8.25	1.50	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
71	EB4	8.25	2.22	7.00	1.41	25.00%	25.00%	50.00%	0.00%	50.00%	50.00%
72	EB5	8.00	2.16	5.25	2.63	0.00%	25.00%	75.00%	0.00%	25.00%	75.00%
73	EB6	9.50	0.58	6.25	1.50	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
74	BF1	9.75	0.50	6.00	1.83	25.00%	75.00%	0.00%	0.00%	25.00%	75.00%
75	BF2	9.75	0.50	7.25	1.50	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
76	BF3	9.50	0.58	7.50	0.58	0.00%	75.00%	25.00%	0.00%	25.00%	75.00%
77	BS1	9.50	0.58	8.25	1.26	25.00%	50.00%	25.00%	0.00%	25.00%	75.00%

78	BS2	9.50	0.58	7.75	2.06	**25.00%**	50.00%	**25.00%**	0.00%	25.00%	75.00%
79	BS3	9.50	0.58	7.00	1.41	**25.00%**	50.00%	**25.00%**	0.00%	25.00%	75.00%
80	BS4	9.50	0.58	7.50	0.58	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
81	BC1	**9.75**	**0.50**	7.75	**0.50**	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
82	BC2	9.25	0.96	8.50	1.29	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
83	BC3	9.00	1.41	9.00	1.41	0.00%	50.00%	50.00%	0.00%	25.00%	75.00%
84	BC4	8.75	1.50	7.75	0.96	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
85	BC5	8.25	1.50	7.75	2.22	0.00%	75.00%	25.00%	0.00%	50.00%	50.00%
86	BC6	**9.75**	**0.50**	8.75	0.96	**0.00%**	100.00%	**0.00%**	0.00%	50.00%	50.00%
87	BC7	9.50	0.58	9.00	0.82	0.00%	25.00%	75.00%	0.00%	0.00%	100.00%
88	BC8	**9.75**	**0.50**	7.75	1.26	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%

The factory managers see several performance attributes are equal important level, as the maximum value of 13 performance attributes in average expectation is 9.75. Three of them were also the highest important in the result of all positions which are TPR3, BC1, and BC8. Lowest important in the factory managers' point of view are LE1 (employees' understanding about companies' target market segments and customer profiles), LE3 (employee involvement in business policy and strategy setting), and TBC4 (offering technical training/ education to customers to help them improve performance). LE1 and LE3 are different from the result from the other positions. For the direction of development, the factory managers see all performance attributes are improved or at lease the same as last two years.

Preliminary analysis – Sales/Marketing manager

The preliminary answers from sales/marketing managers of 1st tier suppliers are depicted in Table 6.

Table 6: Preliminary result for answer collected from Sales/Marketing Manager of 1st tier suppliers.

Performance Attribute		*Expectations*		*Experiences*		*Compared with competitors*			*Direction of development*		
		Average	*SD*	*Average*	*SD*	*Worse %*	*Same %*	*Better %*	*Worse %*	*Same %*	*Better %*
1	LKH1	8.00	0.82	6.75	**0.50**	**50.00%**	50.00%	0.00%	**25.00%**	50.00%	**25.00%**
2	LKH2	7.75	2.06	6.50	1.29	**25.00%**	75.00%	0.00%	**25.00%**	75.00%	0.00%
3	LKH3	7.50	2.38	6.75	1.26	**25.00%**	50.00%	**25.00%**	0.00%	75.00%	25.00%
4	LKH4	9.50	1.00	6.50	2.89	**50.00%**	25.00%	25.00%	**50.00%**	25.00%	25.00%
5	LKH5	7.50	1.00	5.75	2.75	**50.00%**	50.00%	0.00%	**75.00%**	25.00%	0.00%
6	LKL1	7.75	1.89	6.00	0.82	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
7	LKL2	7.00	0.82	6.25	1.50	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
8	LKL3	8.50	1.29	6.25	2.06	**25.00%**	50.00%	**25.00%**	0.00%	50.00%	50.00%
9	LKL4	9.50	1.00	7.50	2.08	0.00%	75.00%	25.00%	**25.00%**	50.00%	**25.00%**
10	LKL5	7.75	**0.50**	5.50	1.73	**75.00%**	25.00%	0.00%	**50.00%**	50.00%	0.00%
11	LC1	8.25	1.26	6.50	1.00	25.00%	25.00%	50.00%	**0.00%**	100.00%	**0.00%**
12	LC2	6.75	2.22	6.75	2.06	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
13	LC3	8.50	1.29	7.25	2.22	**25.00%**	50.00%	**25.00%**	0.00%	75.00%	25.00%
14	LC4	9.50	1.00	7.00	1.41	0.00%	50.00%	50.00%	**0.00%**	100.00%	**0.00%**
15	LC5	7.75	**0.50**	5.75	2.22	**50.00%**	50.00%	0.00%	**25.00%**	50.00%	**25.00%**
16	LE1	7.75	**0.50**	6.25	0.96	**25.00%**	75.00%	0.00%	**0.00%**	100.00%	**0.00%**
17	LE2	7.75	1.50	7.50	2.08	25.00%	25.00%	50.00%	0.00%	75.00%	25.00%
18	LE3	9.25	0.96	6.25	2.36	**25.00%**	75.00%	0.00%	**25.00%**	75.00%	0.00%
19	LE4	9.50	1.00	7.25	0.96	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
20	LE5	8.50	1.29	6.75	2.75	25.00%	0.00%	75.00%	**25.00%**	50.00%	**25.00%**
21	TPP1	9.50	1.00	8.25	2.36	25.00%	25.00%	50.00%	**25.00%**	50.00%	**25.00%**
22	TPP2	**9.75**	**0.50**	**9.50**	1.00	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
23	TPP3	**10.00**	**0.00**	**10.00**	**0.00**	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%

24	TPR1	**10.00**	**0.00**	**9.75**	**0.50**	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
25	TPR2	**9.75**	**0.50**	**9.50**	0.58	0.00%	50.00%	50.00%	**0.00%**	100.00%	**0.00%**
26	TPR3	**10.00**	**0.00**	9.25	0.96	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
27	TO1	**10.00**	**0.00**	**9.75**	**0.50**	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
28	TO2	9.50	1.00	9.25	1.50	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
29	TO3	9.25	0.96	9.00	1.15	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
30	TO4	9.00	1.41	8.25	1.50	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
31	TO5	7.75	2.06	6.25	0.96	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
32	TBC1	8.50	1.29	7.25	2.06	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
33	TBC2	7.25	2.06	7.25	2.06	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
34	TBC3	8.25	1.26	8.00	1.63	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
35	TBC4	6.50	1.73	5.75	0.96	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
36	TBC5	7.50	2.08	6.25	**3.86**	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
37	TE1	7.00	2.45	6.75	2.36	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
38	TE2	8.50	2.38	8.25	2.36	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
39	TE3	**6.00**	2.00	6.25	1.89	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
40	TE4	8.75	0.96	8.00	2.16	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
41	IPI1	9.25	1.50	7.00	3.37	0.00%	25.00%	75.00%	0.00%	50.00%	50.00%
42	IPI2	8.75	1.26	7.25	2.06	25.00%	25.00%	50.00%	0.00%	50.00%	50.00%
43	IPI3	**9.75**	**0.50**	7.25	2.63	**25.00%**	50.00%	**25.00%**	**25.00%**	75.00%	0.00%
44	IPI4	8.75	1.50	6.50	1.00	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
45	IPI5	8.25	1.71	6.50	2.65	**25.00%**	50.00%	**25.00%**	**25.00%**	50.00%	**25.00%**
46	IPI6	9.00	1.41	8.00	1.41	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
47	II1	7.75	2.22	7.25	2.06	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
48	II2	8.00	2.16	6.75	2.36	**50.00%**	25.00%	25.00%	**25.00%**	50.00%	**25.00%**
49	II3	8.25	2.36	6.75	2.75	25.00%	25.00%	50.00%	0.00%	75.00%	25.00%
50	II4	8.00	2.16	6.00	2.45	**50.00%**	50.00%	0.00%	**25.00%**	75.00%	0.00%
51	II5	7.25	1.71	**4.50**	2.08	**50.00%**	50.00%	0.00%	**25.00%**	75.00%	0.00%
52	IIT1	8.00	0.82	7.00	1.83	0.00%	50.00%	50.00%	0.00%	50.00%	50.00%
53	IIT2	8.75	0.96	6.75	1.89	**25.00%**	75.00%	0.00%	0.00%	75.00%	25.00%
54	IIT3	8.75	1.50	7.75	1.71	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
55	IIT4	**5.25**	**3.10**	**2.00**	2.16	**75.00%**	25.00%	0.00%	**25.00%**	75.00%	0.00%
56	IIT5	7.50	1.00	7.00	1.41	**25.00%**	50.00%	**25.00%**	0.00%	75.00%	25.00%
57	ECS1	8.75	0.96	7.50	1.73	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
58	ECS2	9.00	1.15	7.50	2.08	**25.00%**	50.00%	**25.00%**	0.00%	75.00%	25.00%
59	ECS3	8.25	**0.50**	7.25	2.06	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
60	ECS4	8.00	0.82	7.50	0.58	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
61	ECS5	8.00	2.16	6.50	3.00	**25.00%**	50.00%	**25.00%**	**25.00%**	50.00%	**25.00%**
62	ECS6	8.75	1.50	7.50	1.00	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
63	ECS7	8.75	1.50	7.75	1.71	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%
64	ECL1	8.50	1.00	7.50	1.73	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
65	ECL2	7.00	1.41	7.25	1.71	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
66	ECL3	8.00	2.16	7.50	2.08	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
67	ECL4	7.00	1.41	7.00	2.16	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
68	EB1	9.00	1.15	7.00	2.58	0.00%	50.00%	50.00%	**0.00%**	100.00%	**0.00%**
69	EB2	7.00	1.63	6.25	1.50	**0.00%**	100.00%	**0.00%**	**0.00%**	100.00%	**0.00%**
70	EB3	8.00	0.82	7.00	1.15	**25.00%**	75.00%	0.00%	**0.00%**	100.00%	**0.00%**
71	EB4	6.75	**2.50**	5.00	2.83	**25.00%**	75.00%	0.00%	**0.00%**	100.00%	**0.00%**
72	EB5	6.50	2.38	**4.25**	2.22	**25.00%**	75.00%	0.00%	**0.00%**	100.00%	**0.00%**
73	EB6	**5.25**	**3.10**	**4.50**	2.38	**25.00%**	75.00%	0.00%	**0.00%**	100.00%	**0.00%**
74	BF1	9.25	**0.50**	5.75	**3.77**	**50.00%**	25.00%	25.00%	**50.00%**	25.00%	25.00%
75	BF2	9.25	0.96	5.75	**3.77**	**50.00%**	25.00%	25.00%	**50.00%**	25.00%	25.00%
76	BF3	9.50	0.58	5.00	**3.92**	**75.00%**	0.00%	25.00%	**50.00%**	25.00%	25.00%
77	BS1	9.00	1.15	7.00	0.82	**50.00%**	50.00%	0.00%	0.00%	75.00%	25.00%
78	BS2	9.00	1.41	6.75	1.71	**25.00%**	75.00%	0.00%	25.00%	25.00%	50.00%
79	BS3	7.75	1.71	5.00	2.94	**75.00%**	25.00%	0.00%	**25.00%**	75.00%	0.00%
80	BS4	7.75	1.71	5.00	2.94	**50.00%**	50.00%	0.00%	**25.00%**	50.00%	**25.00%**
81	BC1	**10.00**	**0.00**	8.25	0.96	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
82	BC2	**10.00**	**0.00**	8.25	1.50	0.00%	75.00%	25.00%	**25.00%**	50.00%	**25.00%**
83	BC3	8.75	1.50	5.25	3.20	**25.00%**	75.00%	0.00%	**25.00%**	50.00%	**25.00%**
84	BC4	7.75	1.71	5.50	2.08	**0.00%**	100.00%	**0.00%**	0.00%	75.00%	25.00%
85	BC5	7.50	1.91	5.25	1.71	**25.00%**	75.00%	0.00%	0.00%	75.00%	25.00%
86	BC6	9.50	1.00	7.75	1.50	0.00%	75.00%	25.00%	0.00%	75.00%	25.00%

87	BC7	8.00	2.16	7.75	3.20	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%
88	BC8	**9.75**	**0.50**	9.00	**0.00**	0.00%	50.00%	50.00%	0.00%	75.00%	25.00%

There are six performance attributes that all sales/marketing managers see them as highest important with the average expectation is 10.00 combined with the zero standard deviation. This is important to indicate that these performance attributes are the keys that should be focused. These six performance attributes are TPP3 (always deliver on promises made to customers). TPR1 (companies' culture encourages sellers to treat customers with fairness and respect), TPR3 (honest and truthful with customers), TO1 (do not use any proprietary information to our customers' disadvantage), BC1 (Customer Satisfaction), and BC2 (Customer retention/loyalty). This is not that surprising in that all are related to the customers since the sales/marketing is the function in the firm that has the closest linkage to the customers. TPP3 is the only performance attribute that all sales/marketing managers see it completely carried out in the company as can be seen that the experience was scored 10.00 combined with zero standard deviation. Sales/marketing managers saw 26 performance attributes are worse than their competitors; 22 performance attributes are the same as their competitors; the direction of development of 13 performance attributes are worse than previous two years; and 27 performance attributes are the same as previous two years.

In summary, all groups indicated that TPR3 (honest and truthful with customers), BC1 (Customer Satisfaction), and BC8 (Overall response to customer) are important to them. Their answers also indicated that IIT4 (completes the registration of new ideas and products at the Department of Intellectual Property) has been less carried out in the companies and their expectations are also low compared to other performance attributes.

Critical factor index (CFI)

The CFIs were calculated by using the formulas as mentioned previously. The goal of this CFI analysis is to provide support decision making whether which performance attributes are critical and should be focused. The CFIs were calculated from all respondents as well as separately for top management, factory manager, and sales/marketing manager. The compared CFIs results from all respondents and in separated groups are depicted in Table 7 and shown in Figure 5 to Figure 8. The numbers in red indicate performance attributes that are to be seen as critical and figures in green are attributes that are considered to be strengths.

Table 7: Results of Critical Factor Index (CFI).

Performance Attribute		*CFI All positions*	*CFI General Manager/ Top Management*	*CFI Factory Manager*	*CFI Sales/Marketing Manager*
1	LKH1	2.4122	2.9291	3.5229	**0.4536**
2	LKH2	3.2258	3.4830	3.7407	3.0450
3	LKH3	3.0393	3.8478	1.8022	3.7245
4	LKH4	5.4996	13.5755	1.1410	2.3316
5	LKH5	5.2919	6.8399	**7.1517**	3.1016
6	LKL1	3.0527	2.5859	5.3317	1.6973
7	LKL2	2.7017	0.9906	3.9664	1.6316

8	LKL3	3.1215	3.6833	4.1628	2.5689
9	LKL4	2.3848	4.5739	1.4786	1.8260
10	LKL5	2.3435	2.2928	3.4819	0.9077
11	LC1	1.6773	1.7432	1.4560	1.2981
12	LC2	4.5874	3.0341	**5.7692**	6.7891
13	LC3	3.6725	1.0238	4.8368	3.0011
14	LC4	1.5237	2.2174	1.2033	1.1909
15	LC5	2.8024	3.7304	2.8422	1.1921
16	LE1	3.9263	4.9800	2.5976	0.5371
17	LE2	4.4117	3.8413	4.0721	3.9406
18	LE3	5.5753	7.3857	4.8794	1.8766
19	LE4	**0.6659**	**0.8996**	0.4340	0.8248
20	LE5	2.4025	3.4776	0.9789	3.5596
21	TPP1	4.4276	9.3495	1.4614	2.2109
22	TPP2	1.0044	1.5993	0.5944	0.5016
23	TPP3	2.4277	5.0504	1.2479	**0.0000**
24	TPR1	2.6681	5.1974	0.7205	**0.0000**
25	TPR2	1.7681	3.1852	0.4497	**0.2889**
26	TPR3	**0.3226**	**0.4251**	0.4723	**0.0000**
27	TO1	1.6385	3.1151	1.4425	**0.0000**
28	TO2	1.2807	1.7186	0.6751	1.5443
29	TO3	3.3165	7.4357	0.6734	1.1690
30	TO4	2.1379	3.7739	0.5002	2.1981
31	TO5	6.5753	11.9111	4.0287	2.2146
32	TBC1	3.0375	5.1239	0.7205	2.7902
33	TBC2	6.1509	9.1172	1.8038	5.8768
34	TBC3	4.6561	9.8712	1.6620	2.4360
35	TBC4	**8.2721**	13.5477	**9.6709**	2.3733
36	TBC5	**10.9953**	**21.4635**	5.5128	**9.5526**
37	TE1	5.5107	7.2313	0.3943	8.0668
38	TE2	6.1544	9.4856	0.9985	6.4722
39	TE3	7.4204	10.9576	1.1960	6.4717
40	TE4	6.0034	15.0024	0.6832	2.2043
41	IPI1	2.2024	1.5032	1.5527	4.4789
42	IPI2	2.1608	3.0185	1.5487	2.5909
43	IPI3	1.9447	3.6897	0.4989	1.0763
44	IPI4	2.2295	3.2212	0.6740	1.3994
45	IPI5	3.4308	3.5262	2.3399	4.6612
46	IPI6	2.7982	4.7498	1.7867	2.0253
47	II1	3.3113	3.2781	2.1456	5.6315
48	II2	2.7622	3.0983	1.0472	5.6716
49	II3	3.9839	5.5573	0.6928	6.8756
50	II4	4.1048	7.1730	1.2033	5.4982
51	II5	3.2703	3.8465	2.2691	3.8364
52	IIT1	2.5289	3.0955	3.2041	1.7025
53	IIT2	2.3348	3.9057	1.4167	1.7304
54	IIT3	3.5051	7.0952	1.1458	2.6682
55	IIT4	6.0234	5.9489	4.4158	**9.5896**
56	IIT5	1.7800	1.5781	**0.2429**	1.8003
57	ECS1	1.7733	2.7012	0.4302	1.6889
58	ECS2	3.5593	8.5131	0.7968	2.3282
59	ECS3	2.2222	4.2720	0.4513	1.1387
60	ECS4	1.1064	1.7315	**0.2147**	0.5626
61	ECS5	3.0164	2.3564	0.3590	7.0443
62	ECS6	2.4271	3.8157	1.2416	1.5276
63	ECS7	1.5083	**0.8989**	1.5235	2.6682

64	ECL1	2.0106	2.6482	2.5749	1.8571
65	ECL2	3.1604	3.6348	2.6153	3.5477
66	ECL3	3.7309	5.4374	1.2447	5.3669
67	ECL4	4.1353	4.7407	1.0633	4.3753
68	EB1	3.6134	5.7837	2.4520	2.7606
69	EB2	4.1371	5.5250	4.5044	3.2551
70	EB3	1.9784	2.8800	1.4106	1.0714
71	EB4	6.0603	6.8059	3.3956	8.9155
72	EB5	5.3776	5.2135	5.6120	6.6290
73	EB6	6.7404	3.5613	0.6915	**13.0573**
74	BF1	7.8217	21.0377	0.6861	1.5077
75	BF2	**8.3867**	**21.4356**	0.6200	2.8870
76	BF3	7.8781	19.7921	**0.2946**	1.6371
77	BS1	7.2193	**21.3436**	0.6849	0.8752
78	BS2	7.3789	19.5895	1.0743	2.1962
79	BS3	8.1521	19.5895	0.6928	5.0754
80	BS4	8.1069	18.5814	**0.2946**	5.0881
81	BC1	**0.4006**	**0.6879**	**0.2153**	**0.0000**
82	BC2	0.8861	1.0699	1.2493	**0.0000**
83	BC3	4.4289	5.6443	2.2390	4.0655
84	BC4	4.1263	6.9209	1.4996	3.7541
85	BC5	4.1462	5.0689	3.8589	3.5684
86	BC6	0.9001	1.1409	0.4486	1.3472
87	BC7	7.4192	13.1428	0.4774	8.4555
88	BC8	**0.5548**	**0.7470**	0.5404	**0.0000**

Figure 5: Critical Factor Index (CFI) for answer collected from all 1st tier suppliers.

Figure 5 indicates that the highest CFIs for all positions of 1st tier suppliers are TBC5 (share profits gained through collaborative efforts with customers), BF2 (Profit growth), and TBC4 (offer technical training/education to customers to help them improve performance). The performance attributes that are proposed to be critical (in red) are TPR3 (honest and truthful with customers), BC1 (Customer Satisfaction), BC8 (Overall response to customer), and LE4 (encouraged communication with all levels in organization).

CFI – Top management

The CFIs calculated from top management's answers are depicted in Figure 6. The top management CFIs are quite similar to the overall CFIs. From this figure, it can be seen that the CFIs in red are TPR3 (honest and truthful with customers), BC8 (Overall response to customer), BC1 (Customer Satisfaction), ECS7 (A pool of their customers would indicate that the customers are generally satisfied with their organization), and LE4 (encouraged communication with all levels in organization) and four of five performance attributes are also in red while calculating by using the answers from all position, only ECS7 (A pool of their customers would indicate that the customers are generally satisfied with their organization) is different.

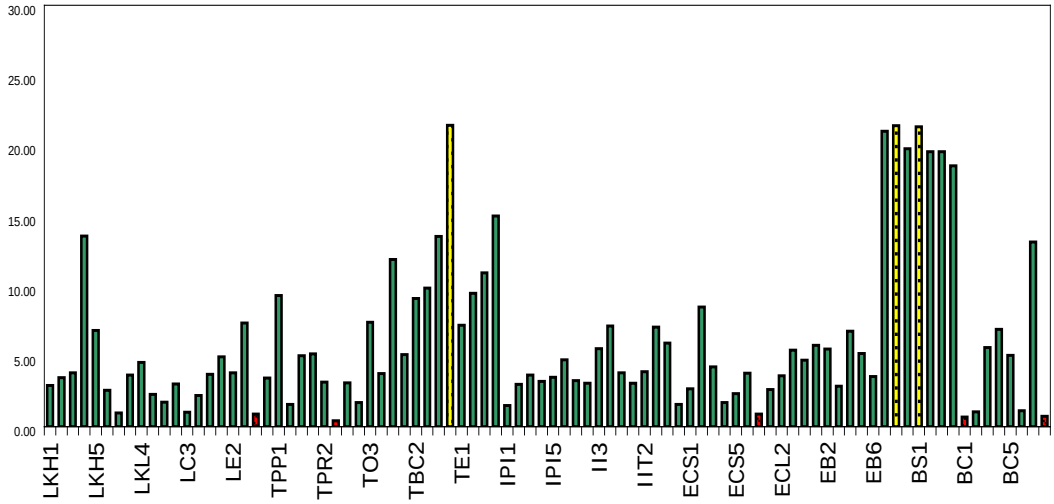

Figure 6: Critical Factor Index (CFI) for answers collected from Top management of 1st tier suppliers.

CFI – Factory manager

The CFIs calculated from factory managers' answers are depicted in Figure 7. The factory managers CFIs are quite different from the others. From the figures, the performance attributes in red are ECS4 (care about what the customer thinks or wants); BC1 (Customer Satisfaction); IIT5 (communicate with other departments to solve the problems in the organization and keep records); BF3 (Profit margin); and BS4 (Market share growth). Only BC1 is also appeared to be high score in expectation by the other positions.

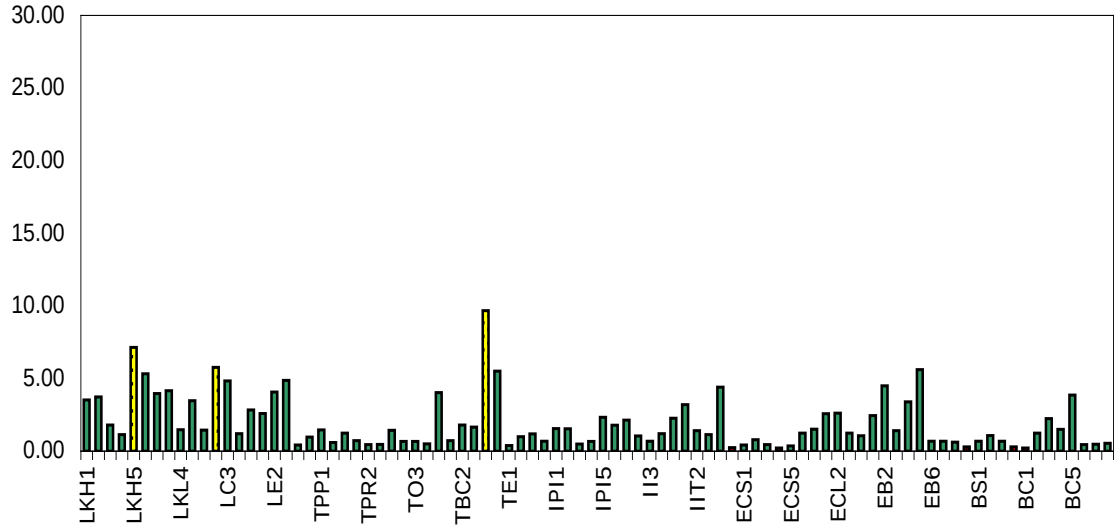

Figure 7: Critical Factor Index (CFI) for answers collected from Factory managers of 1st tier suppliers.

CFI – Sales/Marketing manager

The CFIs calculated from sales/marketing managers' answers are depicted in Figure 8. Some of the performance attributes that answers from the sales/marketing could not be calculated for CFIs since the standard deviation of expectation or experience is zero value. However, the remaining performance attributes were calculated and plot in the graph. The figures in red are TPR2 and LKH1 which are fairness and integrity accurately characterize all dealing with customers; and training for the new staff before starting job.

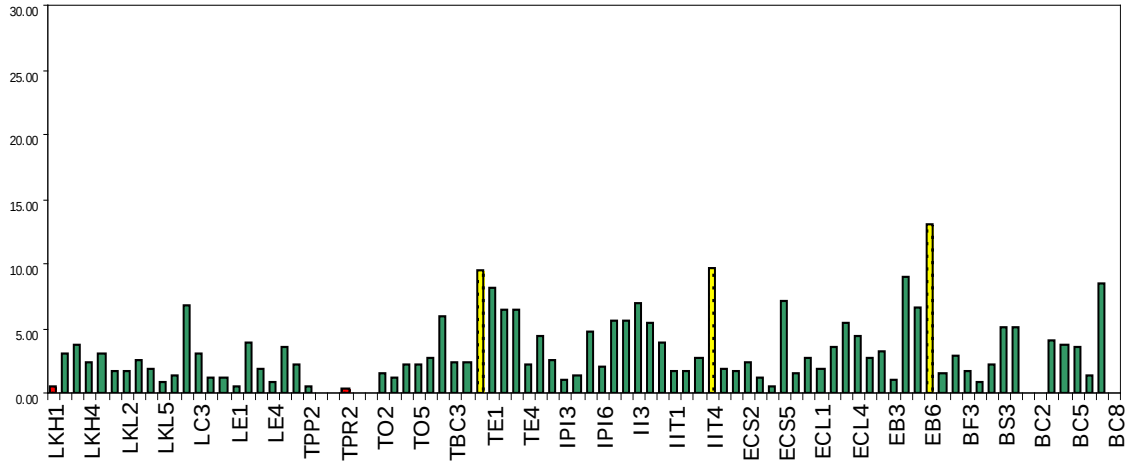

Figure 8: Critical Factor Index (CFI) for answers collected from Sales/Marketing managers of 1st tier suppliers.

DISCUSSION AND FURTHER STUDIES

The results from the analysis can be summarized in Table 8.

Table 8: Summarized Results of Critical Factor Index (CFI).

Supply chain performance		Critical performance attribute			
Elements	**Indicators**	**All**	**Top Management**	**Factory Manager**	**Sales/ Marketing Manager**
Learning and growth	Know-how (LKH)				LKH1
	Knowledge (LKL)				
	Competency (LC)				
	Engagement (LE)	LE4	LE4		
Trust	Performance-to-promise (TPP)				
	Professional-relationship (TPR)	TPR3	TPR3		TPR2
	Openness (TO)				
	Benevolent- collaboration (TB)				
	Empathy (TE)				
Internal process	Process improvement (IPI)				
	Innovation (II)				
	Information technology (IIT)			IIT5	
External structure	Customer satisfaction (ECS)		ECS7	ECS4	
	Customer loyalty (ECL)				
	Brand (EB)				
Business performance	Financial (BF)			BF3	
	Sales (BS)			BS4	
	Customer (BC)	BC1 BC8	BC1 BC8	BC1	

According to the results from all respondents, the 1st tier suppliers in the Thai automotive supply chain should focus on the engagement in learning and growth element, professional relationship in trust, and customer in business performance element. However, there are some results analyzed from different positions that appear to have some different critical performance attributes. This is understandable as different groups have different points of view. For instance, sales/marketing managers focused on the know-how in learning and growth element (LKH1: Training is required for the new staff before starting job.) because they are the contact point to the customer. Therefore they require having know-how in order to explain or answer the customers' questions about products and company. Factory managers required the information technology in the internal process element (IIT5: communication with other departments to solve the problem in the organization and keep record) because they manage the factory that produce the products where the problems that occur in the manufacturing process need to be solved quickly and always need other departments to be involved.

The results from this questionnaire process are still preliminary. The answers from the automaker companies are few and cannot be analyzed. In future researches, the answers from the automakers will be collected and analysis will be made. In the long run, the causal relationship between the supply chain performance elements focused on the critical performance attributes will be studies.

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G1 – Sustainability

G1.1 **Completeness of sustainability reports: The examples of Polish and international companies**
Agnieszka Leszczynska

G1.2 **An analysis of the effectiveness of supplier innovation as a competitive strategy for an enterprise under conditions of high-turbulence**
Namkuy Park

G1.3 **Coherence in control of information security (COINS)**
Yngve Monfelt

G1.4 **Correlation of actors' resource-bases with their networking tendencies – Views on the bioenergy business**
Matti Lehtovaara

COMPLETENESS OF SUSTAINABILITY REPORTS: THE EXAMPLES OF POLISH AND INTERNATIONAL COMPANIES

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ABSTRACT

Sustainability reporting, which integrates information on the economic, environmental, and social performance of a company into a single publication, is a new trend in corporate reporting. This article discusses research evaluating the quality and completeness of sustainability reports published by Polish and international companies. In the case of Polish organizations that have recently begun to present sustainability reports, their completeness was assessed according to the GRI guidelines. In the case of international companies, the reports published in 2005 and 2010 were compared.

Keywords: sustainability reports, corporate sustainability, reporting

CORPORATE SUSTAINABILITY AND REPORTING

Defining sustainability, corporate sustainability

The concept of sustainable development, generally used at the macroeconomic level, presupposes that it is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. As a general concept, sustainable development encompasses three interrelated and complementary fundamental approaches: economic, environmental, and that of social development. Economic sustainability is fundamental to financial success, e.g., in the long run an organization simply cannot survive if its expenditure exceeds income. Social sustainability embodies the humanitarian context and relates to issues of poverty, income inequality, disease, education, as well as access to clean water. Environmental sustainability considers the impact on the quality and quantity of natural resources, improved pollution and emissions management (Townsend, 2008). Sustainable development is the development that attempts to bridge the divide between economic growth and environmental protection, while taking into account other issues traditionally associated with development. It seeks to develop the means of supporting economic growth while supporting biodiversity, relieving poverty and without using up natural capital in the short term at the expense of long-term development. Indeed, there is a growing consensus that firms and governments in partnership should accept moral responsibility for social welfare and for promoting individuals' interest in economic transactions (Aras and Crowther, 2009).

While at the macro level there is a certain vision of what sustainable development is, at the level of organizations this concept has not been made sufficiently specific. Definitions of corporate sustainability vary on the degree to which they classify corporate sustainability as either ecological concern (Shrivastava, 1995) or as social responsibility of an organization (Carroll, 1999), or broaden the concept of corporate sustainability to integrate corporate economic activities with organizational concern about environment (van Marrewijk, 2003).

The present paper is based on the assumption that a company is sustainable if its practices contribute positively to the welfare of a society and have as small an environmental impact as possible. Sustainability therefore is currently used to refer to a company's ability to maintain and demonstrate a positive economic, environmental, social performance over the long-term.
The economic dimension refers to financial viability. It encompasses issues of competitiveness, job and market creation, and long-term profitability. Economic sustainability is increasingly understood to refer to generating added value in a wider sense rather than conventional financial accounting. The economic and financial aspects of sustainability may therefore encompass (ICC, 2002):

- reducing operating costs through the systematic management of resources,
- reducing the cost of doing business and attracting new business through rigorous business integrity policies,
- attracting a new range of investors,
- offering opportunity for inclusion in socially responsible investment indices.

The environmental dimension focuses on an organization's impact on living and non-living natural systems, including eco-systems, land, air. Environmental responsibility involves more than compliance with all applicable government regulations or even initiatives such as recycling or energy efficiency. It involves a comprehensive approach to a company's operations, products, facilities that includes eliminating waste and emissions, maximizing the efficiency and productivity of all assets and resources (Jamali, 2006).
The social dimension – centers on the impact of an organization on the social systems within which it operates. The expectations of diverse groups of internal and external stakeholders as well as interest groups comprising civil society are genuinely considered and skillfully balanced.

At the practical level, positive results achieved in all the mentioned aspects are a possible indicator of sustainable development in an organization. Thus, an organization should achieve positive financial results, at the same time implementing wide-ranging activities oriented towards the development of employees and support of a local community, as well minimizing its negative impact on the environment.

Sustainability reporting

Over the last decade, more and more organizations have moved toward monitoring their performance on environmental and social aspects. Sustainability reports become new trend in corporate reporting. Two schools can be distinguished in this area. The first school comprises those who think such reporting can usefully be based at the organizational level because the entity is what we are used to, social accounting at this level offers a challenge to financial accounting and the entity is the locus of decision-making, and probably power (Gray, 2006). The second school believes that the economic organization is the problem and that all reporting needs to be based on regions, ecological regions and local eco-system, and the boundaries between organizations must, consequently be re-drawn or even removed (Gray and Milne, 2004).It is critical to collect and analyze information on sustainability for improved resource allocation decisions. This information should then be included in internal sustainability reports to improve managerial decision-making regarding processes and

products. How companies perform on sustainability is also an important factor for external stakeholders since they are affected by organization actions.

Sustainability reporting is based on the premise that organizations are not only connected with one group of stakeholders, but are also related to other groups/stakeholders. Those groups may be interested in an organization's results and activities (plans, programmes) it undertakes in various areas. Stakeholders, and particularly investors, generally require a clear demonstration that (a) sustainability impacts are well managed, and (b) sustainability initiatives are aligned to strategy and support future performance. Organizations themselves also benefit from reporting non-financial information. It can allow them to track their progress against specific targets and help them convey information on corporate sustainability strategy internally and externally communicating all relevant efforts. If we cannot develop a consensus definition of sustainable development in organizations, we can still proceed by having a consistent tool for monitoring progress.

Literature, as well as consulting firms' offers, describes a number of methods/methodologies to assess the level of organizations' sustainable development. The most frequently named are: the World Business Council for Sustainable Development, the Global Environmental Management Initiative, the Coalition for Environmentally Responsible Economies are among the most frequently named. The common characteristics of a majority of them include (Format):

1. An explanation of how sustainability is connected to the overall operational strategy of an organization and the provision of sustainability targets. The challenge is to ensure that in mainstream reporting the sustainability information included is strategically important. Targets are important to ensure and demonstrate that sustainability issues are taken into account when making investment decisions.
2. Five key environmental indicators, which all organizations should consider reporting, they are: greenhouse gas emissions, energy usage, water use, waste and significant use of other finite resources.
3. Other key sustainability information should be given where the business or operation has material impacts. The Framework is not prescriptive in this respect to avoid the provision of irrelevant information and a "one-size-fits-all" approach.
4. To aid performance appraisal, industry benchmarks for the key performance indicators when available.
5. The up-stream and down-stream impact of the organization's products and services: the sustainability impacts of its suppliers and the use of its products or services by customers and consumers.

The most widely recognized and acknowledged is the GRI Guidelines. The GRI Guidelines are the first framework for providing guidance for disclosure about sustainability performance. More than three-quarters of the Global Fortune 250 companies follow the Guidelines. It is based on the evaluation of economic, ecological, and social performance. The GRI guidelines suggest that reports should cover the following indicators:

- vision and strategy of an organization on sustainable development, including a relevant statement by the CEO or equivalent senior manager;
- profile of the organization and the report itself, giving an overview of organization's activities and report's scope;

- organization's governance structure, including overarching policies and management systems in place to implement the vision of an organization regarding sustainable development;
- performance of an organization during the reporting period, with information grouped under indicators according to the conventional definition of sustainable development.

Some examples of indicators for three key areas of sustainability including:

- economic: wages and benefits, job creation, expenditures on research and development, investments in training, forms of human capital, traditional financial information,
- environmental: impacts of activities, products on air, water, land, biodiversity, human health,
- social: workplace health, employee retention, human rights and diversity, wages, working condition.

The GRI Guidelines offer (a) core content for reporting that is relevant to all organizations, and (b) indicator protocols that advise on definition, scope, and compilation methods to help organizations to ensure a meaningful and comparable reporting on indicators. No organizations expected to report on all the elements in the guidelines, but they are expected to expand their reporting with time. The evaluation of sustainability reports presented by organizations is based primarily on their completeness: Is the information complete and accurate enough to assess an organization's performance? As additional evaluation criteria GRI suggests:

- materiality: Does the sustainability report provide an account covering all the areas of performance that stakeholders need to judge the organization's performance?
- responsiveness: Has the organization responded coherently to stakeholder's concerns and interests?

STUDY METHOD

Scoring system

In deciding on a method for evaluating organization reports, the author looked at several potential metrics. The GRI methodology was adopted as the basis for evaluation because it is generally used and available (69 percent of the largest companies by revenue follow the GRI Sustainability Reporting Guidelines). The range of points used in evaluating sustainability reports was between 0 and 4. Points were assigned as follows:

- when a specific topic was not mentioned In the report, no points were assigned,
- brief or generic statements received 1 point,
- more detailed coverage received 2 points,
- extensive coverage received 3 points,
- 4 points was assigned to topic when coverage was full.

It should be stressed that the study did not evaluate results achieved by individual organizations, but exclusively the way (precision, reliability) in which they presented

information. The maximum score was 312 for 78 topics. The number of topics and the maximum possible score for each of them are presented in Table 1.

Table 1: Scope of the study.

Section	**Topics**	**Maximum points**
Vision and strategy	1	4
Profile, parameters	21	84
Governance	5	20
Economic performance	8	32
Environmental performance	18	72
Social performance:	25	100
Labour practices	9	36
Human rights	6	24
Society	6	24
Product responsibility	4	16

Studied reports

A web-based search was performed to collect all sustainability reports published by polish and international organizations. In total, 12 Polish reports were included in the assessment for 2010 (see Table 2). All organizations in this group were first-time reporters. The study of international organizations covered 17 companies. The reports analyzed in this group came from 2005 and 2010. 10 reports of 2005 were examined. Half of the organizations in this group did not prepare reports in the following years. 5 organizations that published their sustainability reports also in 2010 were subject to a comparative examination. In 2010, 12 additional organizations that had not earlier presented sustainability reposts were included in the study. According to the time of preparing the report, the GRI guidelines or GRI framework were used.

Table 2: List of the analyzed reports.

	2005	**2010**
International organizations	SAB Miller Cosmote Coca Cola British American Tobacco Atlas Copco BP Henkel Skoda Auto Palfinger World Steel Industry	Samusung IKEA SAB Miller Cosmote Coca Cola British American Tobacco Atlas Copco Daimler Chrysler Toyota Wal Mart Siemens Asia Development Bank Confederation of European Paper Industries HSBC Holdings US Army Hitachi Jacobs Engineering Group Sony Ericsson
Polish organizations		Telekomunikacja Polska TP Lotos Górnośląska Spółka Gazownictwa PKN Orlen Grupa Żywiec Apator Autostrada Eksploatacja Balex Metal Bank Gospodarstwa Krajowego Axel Springel Polska Polpharma

RESULTS

General results for individual areas are presented in Figure 1.

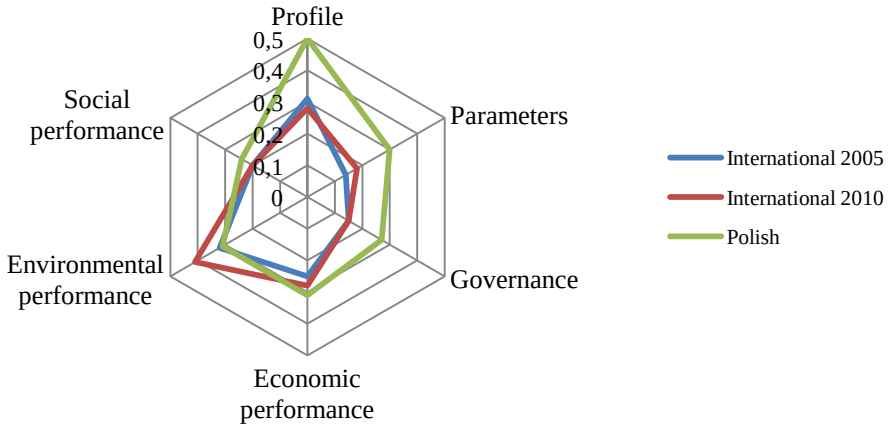

Figure 1: Average scores per group.

The greatest increase was recorded for SAB Miller, reflecting on 12 percent improvement in overall report content over 5 years. Telekomunikacja Polska, which provided the most balanced report (58 percent), should be indicated as a benchmark.

On the whole, the introductory statements did not concern sustainable development, but presented an organization's profile. The reports described the organization's major products, the countries or regions where the organization's operations are located. They referred to the scale of the reporting entity; in terms of number of employees, net sales, and volume of products or services. It should be noted that, with time, organizations presented less detailed introductory information, indicating only their branch and well-known brands. This is reflected in a significant disproportion between the Polish organizations (50%) that reported for the first time and those having reported several times (22%).

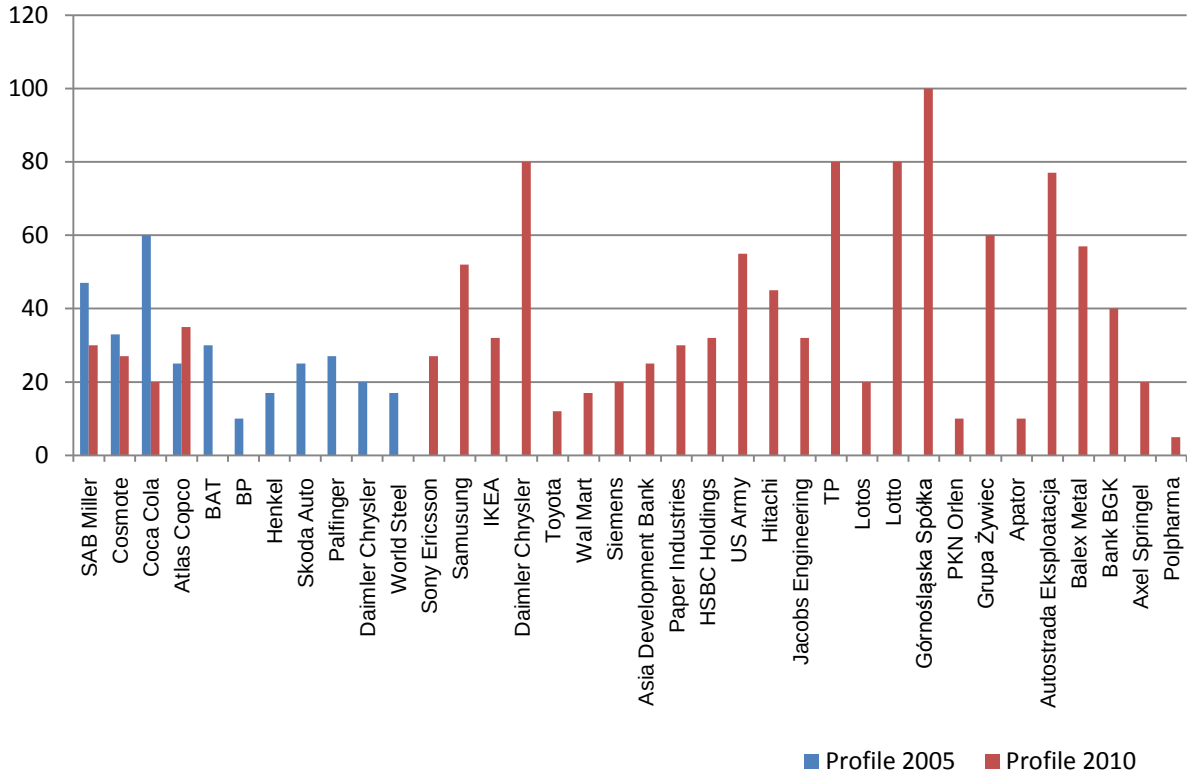

Figure 2: Results in the profile area.

In terms of the reporting parameters, the analyzed reports most frequently presented the reporting period, the reporting cycle, and the methodology used in reporting. Sporadically, the limitations of reporting and evaluation of the report completeness is also included. In the international organizations external verification of reports was performed much more frequently. The most detailed data in this area was presented by TP (70%) and Lotto (72%) – Figure 3. In the case of international organizations, in the area of parameters a 4% improvement was noted in 2010 in comparison to 2005; in both periods the increase was 13% in the studied organizations. The organizations in this group presented their mission, principles and codes of conduct in a more detailed way. The reference to the reporting entities' programs and procedures pertaining to the environmental and social performance can be found here, as well as the list of memberships in trade association.
The Polish organizations, in turn, are more focused on the power structure. The mechanisms of presenting recommendations to the management were the least defined in this area. The reports rarely included information on key issues and concerns identified as a result of stakeholder consultation or how those issues and concerns might possibly influence the organization's internal policies.

On the whole, the average score on the internal governance was 21% (2010). BGK's report scored 70 percent. The reports of Atlas Copco were one inclusive regarding relevant information in both reporting periods.

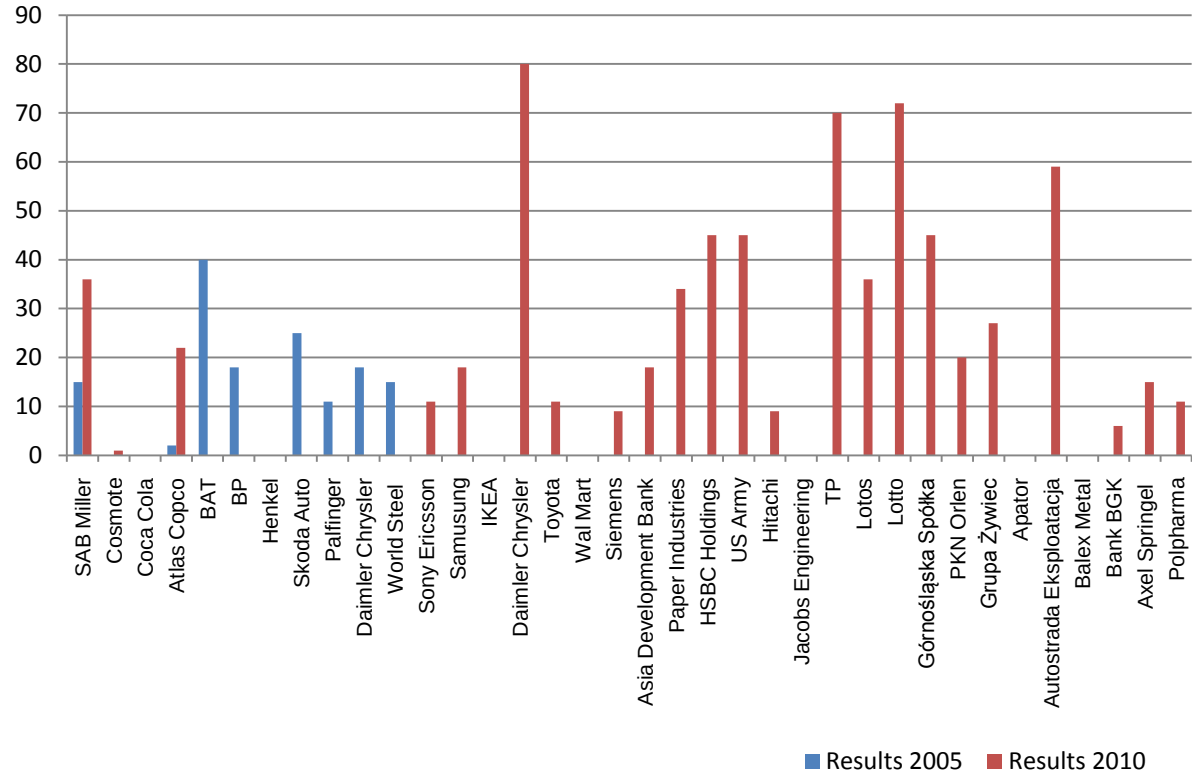

Figure 3: Results in area parameters.

Economic performance

The ways of presenting financial results of the organizations varied (Figure 4). Some of them provided detailed information (Samsung 68%, Lotos 87%), while others gave only the net sales results or referred to other financial reports (e.g. annual) (Axel Springer Polska, Jacobs Engineering). In this area, the report of the US Army is particularly noteworthy: despite the fact that data in this sector is to a great extent classified, the report presents quite detailed financial information (53%). In the economic area, the organizations most frequently focused on their income and contribution to the development of local communities, the least frequently – on the risk related to the climate change and to the organization's retirement obligation.

All reports included information about donations and charitable contributions that their organizations had made during the reporting period. In many cases, however these contributions were not referenced in financial terms or no relevant breakdown of the total amount was available. The average score was 28 percent, showing 3 percent rise from the previous assessment period.

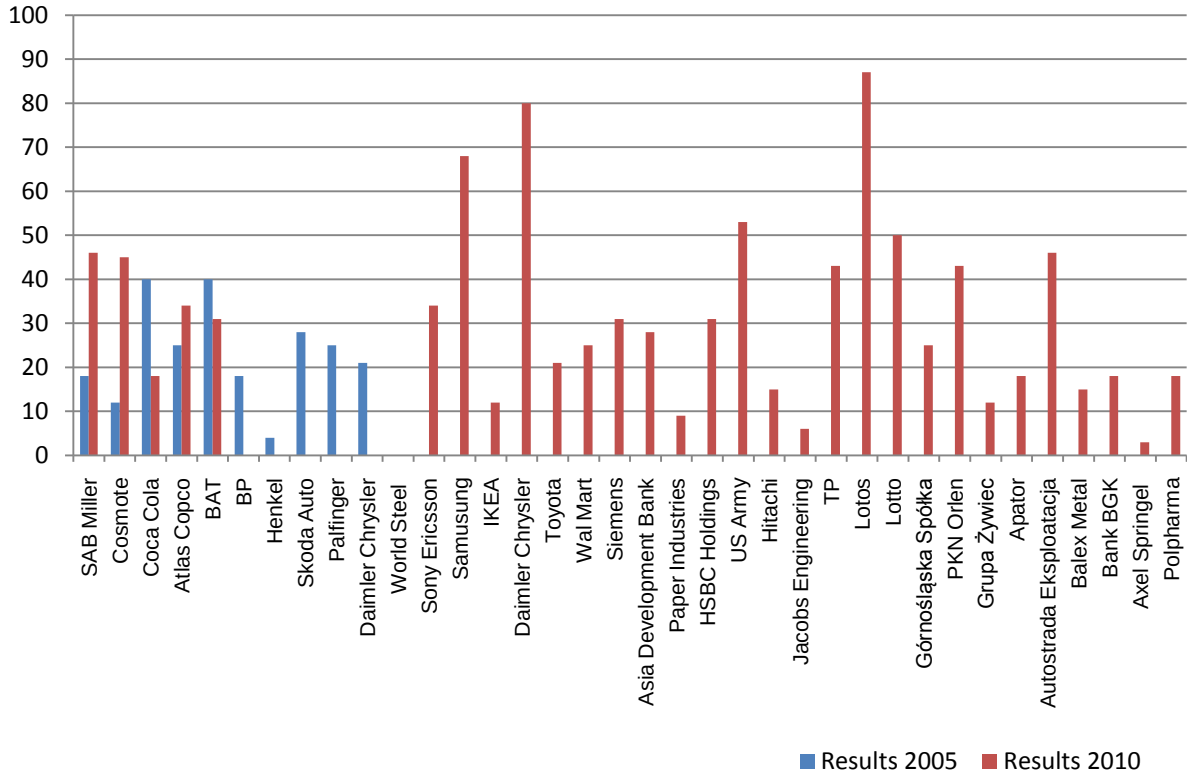

Figure 4: Evaluation of the reports in the economic sphere.

Environmental performance

The greatest gap between the Polish and international organizations concerns the environmental sphere. The average score was 31 percent for polish and 41percent for international (Figure 5). The indicators most often cited were: energy consumption, water consumption, and CO_2 emissions. The reports tend to disclose soil usage and the influence on biodiversity. All the organizations presented their activities related to environmental protection in a very detailed way. The reports presented by production enterprises, included information on developing and introducing on the environment-friendly products. The results of evaluation clearly reveal that Samsung (84%) and British American Tobacco (83%) are leading the way in environmental performance reporting. Lotos (69%) is heading the group of Polish organizations. The organizations publishing reports in 2005 and 2010 showed a significant 13% increase in reporting ecological indicators.

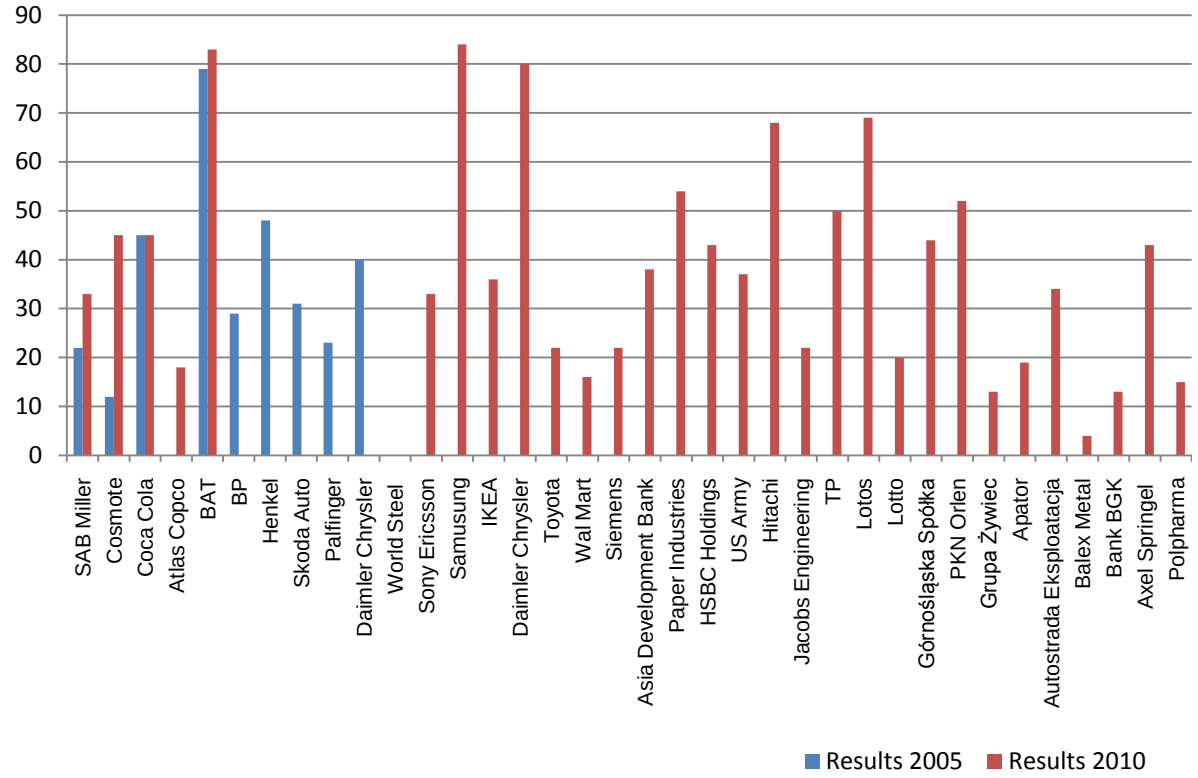

Figure 5: Evaluation of the reports in the environmental sphere.

Social performance

In the social sphere, the Polish and the international organizations obtained similar results (Figure 6). In the case of international organizations, a 12% increase in detailedness of reporting could be observed over the last 5 years. The report of the British American Tobacco and Lotos scored the highest in the social sphere. The results obtained for the sub-areas evaluated in this sphere were listed in Table 3.

Table 3: Results obtained in the social sphere sub-areas.

	Polish	**International 2005**	**International 2010**
Labor market	35	26	27
Human rights	25	14	16
Society	18	22	15
Product responsibility	19	18	23

The reports generally provided more information on internal labour practices and working environments than on broader social issues associated with their companies' business operations. In particular, most reports included analysis of the organization workforce in terms of factors such as gender, age, and the degree of education. Information on training courses was also presented. The area of human rights and society scored the lowest. In the former case, most reports include reference to freedom of association and to discrimination of employees. However, only few organizations (Coca Cola) include the human rights aspect in their reports. The results offered little discussion on their organizations' respect and protection for basic human rights or the sphere of influence of the reporting entity. In the

social area the organizations focus on the activities related to local policy: management programs, influence on local communities, and lobbing. The reports omitted information regarding bribery and corruption, anticompetitive behaviour and how companies deal with such matters. Significantly, only 3 reports of the Polish organizations indicated anticorruption activities. In the area of product responsibility, information provided by the Polish organizations scored much lower: their reports are more general and selective. Also, less attention was given to the issues such as preserving customers' health and safety during the use of products, product labelling, and consumer privacy.

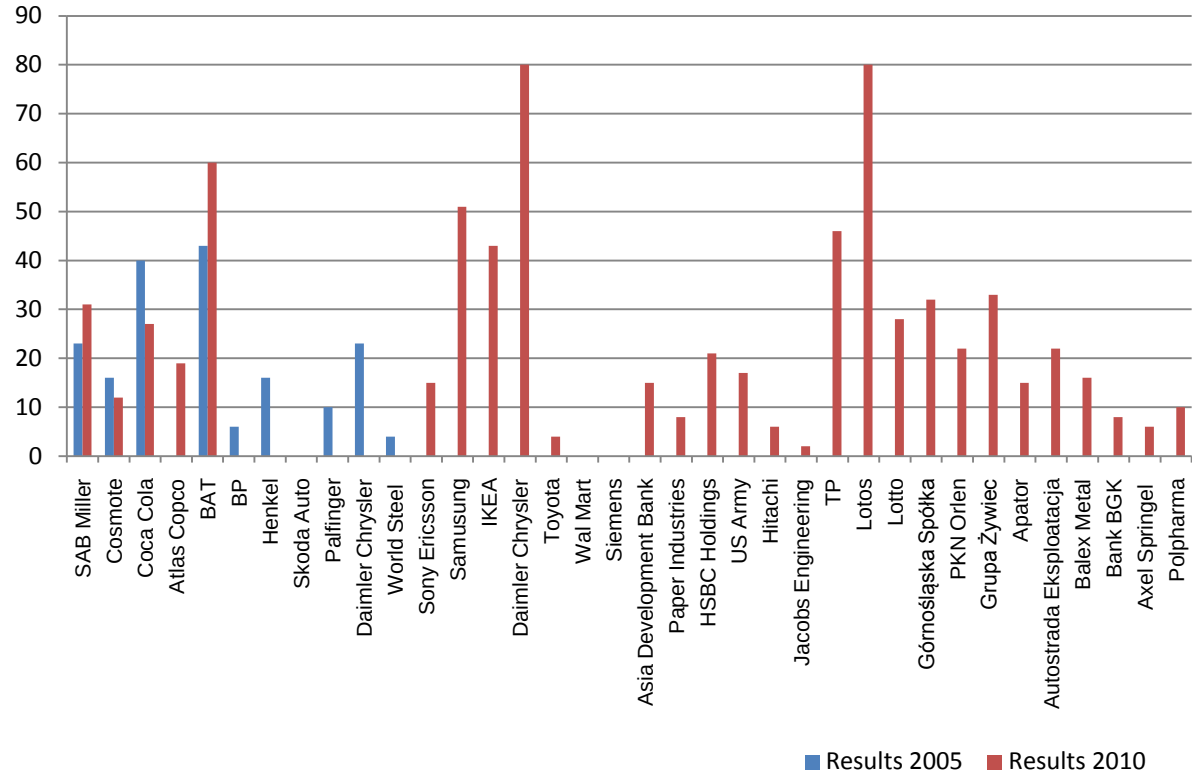

Figure 6: Evaluation of the reports in the social sphere.

Possibility of improvement

Undoubtedly, in the recent years an increase in the detailedness of the presented sustainability reports could be observed. This concerns especially the environmental sphere. However, there is still much room for improvements. In the economic sphere, the information related to the climate change is omitted. In the social sphere the least precisely reported information is that related to anticorruption policy, human rights (including children labour, forced labour), and support given by the organizations to political activity. In the case of the Polish organizations, the gaps in reporting concern social issues and product safety.

Some authors point to the need for the global architecture of standards, or normative framework, to emerge. In our opinion, the present reporting standards meet the needs of the organizations and stakeholders. The development of those standards over the recent years has made them appropriate for covering all the relevant issues.

CONCLUSION

Sustainability reporting is gaining acceptance among a growing number of organizations. The analysis of the number of reports published on the www pages showed a ca. 70% increase for international organizations over 5 years. An increase in this kind of reporting concerns also the countries where the experience of organizations with sustainability reports is much shorter. No sustainability reports of Polish organizations dating from 2005 were found, while in 2010, there are already 12 such reports. Reports are published by production enterprises (Żywiec) and by service organizations (Autostrada). We also meet reports in such untypical trades as the military or games of chance. A number of reports published by the international organizations were not integrated – financial reports, social reports and environmental reports were published separately. However, the reports by the first-timer reporters showed an integrated form.

Contrary to expectations, the Polish organizations, although they had less experience in sustainability reporting, scored higher in some of the issues. This is due to the fact that, basing on the GRI Framework, they provided exact information according to the successive points (issues) included in the Framework. International organizations adopted a holistic approach, focusing on selected aspects. They often omitted information on the profile of their activity and governance. However, the data concerning the environmental sphere and labour market was presented very precisely. The earlier indicated gaps in the social sphere result from the fact that most of the organizations operate in European Union, where human rights are clearly and fully protected by legal obligations. The ecological part of the reports should be evaluated as very good. The reports tend to highlight an improvement in their environmental results in the consecutive years. They also present extensive information on activities and campaign aiming at environmental protection.

Considering the reports prepared in 2005 and 2010, a quality improvement can be observed. An in-depth analysis of those reports showed an increase in the detailedness of reporting in the fundamental spheres, i.e. economic, environmental, and social, by 7, 13 an 12 percent, respectively. The presented study of sustainability reports indicate that there has been improvement in the comprehensiveness of the sustainability reports published by international organizations. The development of the global standards will enable organizations that have not reported so far to prepare a report. The example of the Polish organizations show that such first-time reports may be of a very high quality; the reports of some organizations can become a benchmark for others. What is more, the Polish organizations that already have experience in sustainability reporting enjoy a competitive advantage at a national level – and they can encourage other organizations to follow their example.

The potential directions of the improvement of the sustainability reports quality are related to logic, organization, editing and reliability (Figure 7). The logic of reporting requires the use of non-contradictory statements, precise determination of the scope of a report, improvement in the completeness of documents. In particular, this concerns including all information in the report, without omitting data that are unfavourable for an organization of difficult to identify. Information should be presented in as detailed and precise way as possible, and not in the form of general statements. To organize a report, it is necessary to

base on a selected method of reporting and comply with reporting standard. Editing of a report is related to using references and to the report form. In order to improve the clarity, it is recommended to group appropriate information, present it in tables, charts, and include also historical data. An improvement in the reliability of a report consists in obtaining its external confirmation. It is also important to combine environmental, financial and social report into one, integrated document and to make it available to the public. Unpublished reports loose their power of influence and serve only the internal purposes of an organization. In order for integrated reporting to be a viable and useful activity for companies, it must be underpinned by standardized financial and ESG reporting frameworks. Financial reporting standards, such as International Financial Reporting Standards (IFRS) and US Generally Accepted Accounting Principles (U.S. GAAP) and ESG reporting frameworks, principally the GRI Guidelines, will act as structural supports for potential integrated reporting frameworks.

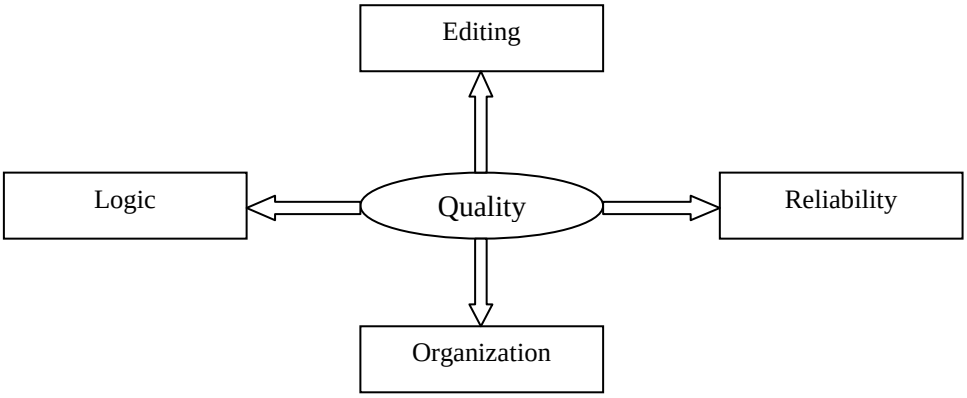

Figure 7: Directions of the sustainability reports quality improvement.

Due to an increase in the interest in sustainability reporting it is possible to predict that the sample of sustainability reports in the following years will be larger than in 2010.

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AN ANALYSIS OF THE EFFECTIVENESS OF SUPPLIER INNOVATION AS A COMPETITIVE STRATEGY FOR AN ENTERPRISE UNDER CONDITIONS OF HIGH-TURBULENCE

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ABSTRACT

Suppliers are the key source of both process and product innovation for an enterprise. The innovation of suppliers can contribute to the long-term competitiveness of the enterprise. For many enterprises, turbulence is a major factor in their business environments, and it should be considered in the development of strategies for an enterprise. In this paper we evaluate the effectiveness of supplier innovation as a strategic tool to enhance the competitiveness and viability of enterprises operating under the influence of high turbulence. Our research looks at different supplier and sourcing attributes, such as, the number of sourcing options, the supplier innovation creation and adoption capabilities, the supplier innovation speed, as well as, their interaction with market turbulence, on the ability of an enterprise to create innovative products that enhance its long-term competitiveness. Our analysis is performed utilizing data generated from agent-based simulation experiments and case-studies. Our results demonstrate the strong of influence of supplier and sourcing factors on the effectiveness of supplier innovation as a long-term competitive strategy.

Keywords: strategic management; supply-chain management; technology management; innovation management

INTRODUCTION

The development of new products and improvement of existing products, are considered to be critical to the survival of a company facing tough competition. Due to an increase in competition and rapid advancement of technology, innovation and new product development are becoming the essential strategies for the management of the companies to survive in the industry (Peterson et al., 2003). Innovation is an effective tool that an enterprise can utilize to maintain its competitive position in the market. The position of the company in the market can be influenced by the frequency of releasing new or improved products (Pisano, 1997). As a result of increased customer communications in many markets today, customers are inundated with many product choices, resulting in shorter product life cycles and rapid changes in customer

preferences. Product dynamism refers to the continuous change in the product which is characterized by speed and magnitude of technological change in the product. To cope up with competition and dynamic change in market demand many firms are adopting open innovation which involves collaboration with external entities, like customers, suppliers, universities, research organizations and competitors (Vonhippel, 1988). Many companies are switching towards open innovation models, from traditional closed innovation models, to increase their level of innovation and retain competitive position in the industry. Open innovation involves interaction of firms with several external entities such as customers and suppliers to generate new ideas to improve existing products and develop new products. The number of patents granted to the firms using open innovation models is significantly higher compared to those granted to firms utilizing only internal resources to innovate (Chesbrough, 2003).

Suppliers are a significant source of external innovation to a firm (Park and Oduntan 2010). Of all the different types of external sources of collaboration adopted for innovation of the product, suppliers innovation has the most significant impact on the performance and success of the firm (Park and Oduntan, 2010). Supplier collaboration increases the technology knowledge available to a firm, which helps it reduce the product development time by identifying the potential problems beforehand (Kessler et al., 1996). Ragatz et al. (2002) found that involvement of suppliers in innovation process result in benefits such cost reduction, improved quality and sales increase. The successful development of supplier collaboration involves shared training, mutual trust and commitment, rewards and agreed performance measures (Ragatz et al., 2002). Peterson et al. (2003) argued that the integration of suppliers into new product development activities can reduce the risk involved with technology which is at its formative stage. Companies which share the “technology road-maps” with the suppliers can help the firms to introduce first product with new technology which is considered as a competitive advantage (Peterson et al., 2003). Supplier innovation reduces potential problems during the early stages of development (Wasti et al., 1999).

Although significant benefits can be achieved through the use of supplier collaboration, for a company seeking to leverage the innovation of its supplier through collaboration, it is necessary that the correct attributes are considered in the design of supplier collaboration relationships. The objective of our research is to gain a better understanding of the factors that an enterprise must consider in its design of a supplier collaboration relationships. Results of our research will identify, for companies seeking to utilize supplier collaboration, the factors that need to be considered in selecting suppliers and the types of supplier relationships that will result in improved product development performance over the long-term.

LITERATURE REVIEW

The level of supplier integration in product development ranges from simple consultation in the design of products, to the independent development of entire modules by suppliers (Wagner 2010). Research shows that supplier involvement in new product development enhances the customer firm’s innovation performance along various dimensions. Supplier involvement in the product development reduces development cost, development time, and cost of the product to

the customer firm (Wagner 2010). Supplier involvement in innovation helps firms penetrate at a faster rate into the new markets, share risks among suppliers and increase the competency level (Wagner Hoegl). Park and Oduntan (2010) identified the following key attributes for innovative suppliers.

- Innovative suppliers are responsible for improving the attributes related to the module they innovate.
- The modules supplied by innovative supplier have unique attributes which can be perceived by the customer.
- Innovative suppliers identify the features and attributes of the module as desired by the customers and work for improving the attributes.
- Innovations in the modules supplied by innovative suppliers can influence the buying decision of the customer.

Clark and Fujimoto (1991) classified the parts related to auto industry into three types based on the extent of involvement of suppliers in their development:

- "Detailed control parts" in which development is performed entirely by the customer i.e., the auto manufacturer
- "Black-box" parts in which specifications and interface requirements are given by customer. "Supplier proprietary" parts whose development is performed entirely by the supplier (Clark et al., 1991).

Clark and Fujimoto (1991) also introduced "grey box" parts whose development is performed both by supplier and customer. Kaufman et al. (2000) proposed a typology for the classification of suppliers based on the collaboration and technical expertise of the supplier. Commodity suppliers possess lower technical expertise and collaboration is low. Collaboration specialists are detail control part manufacturers who possess lower technical expertise but higher collaboration is required. Technology specialists are proprietary parts supplier with high level of expertise and low collaboration. Problem solving suppliers are black-box part suppliers with high level of expertise and high collaboration (Kaufman et al., 2000). Fredrik et al. (2002) identified nine factors which are crucial for the success of new product development based on the case study of an auto manufacturer. Proactive role of the supplier, role of auto manufacturer as coordinator, linkage between production and development, supplier's support to other auto manufacturers are the four key factors which need to be investigated before making the decision to involve suppliers in new product development (Fredrik et al., 2002). Liker et al. (1996) identified several variables, including tier structure, degree of responsibility, inter-company communication, intellectual property agreements and supplier membership which play key role in supplier integration and the success of new product development projects.

Primo et al (2002) found that factors such as current technological capabilities and innovation level required by the customer firm are critical for analyzing the level of involvement of suppliers in the product innovation. Wagner et al. (2006) categorized the critical factors for the success of new innovation projects with the involvement of suppliers into two domains such as factors related to organizational level and management of suppliers in the project. The architecture of the product design and interaction with suppliers during innovation process

must be in coherence (Boutellier & Wagner, 2003). Modular architecture of the product allows one-to-one mapping of the functional requirements to the physical components and allows standardized interfaces between modules (Ulrcih,1995). Modular product architecture enables easy upgrade and substitution of components allowing the customer firm to divide the design and development activities to the suppliers efficiently (Schrader & Göpfert, 1997, Von Hippel, 1990). With the integral product architecture there is more than one physical component which performs a single functional requirement (Ulrcih ,1995), which makes the task of dividing the design and development of components complex because a change in one functional requirement necessitates changes in more than one physical components (Schrader & Göpfert, 1997, Von Hippel, 1990). Supplier involvement strategies depend on product architecture, design and interfaces with suppliers ranging from "none" and "white box" to "grey box" and "black box" supplier integration (Monczka et al., 2000).

Henderson and Clark (1990) distinguished the R &D capabilities of the suppliers as architectural and component knowledge. Component knowledge refers to the capability of the supplier to design and manufacture the component for the final product, but not the final product itself. Architectural knowledge refers to the ability of the supplier to integrate and coordinate the knowledge between other suppliers and customer firm. Supplier assessment based on their manufacturing, assembly and logistic expertise is vital for supplier selection in the new product development process (Monczka et al., 2000). Wasti and liker (1997) found that frequency of communication between supplier and customer during the new product development process influence the decision making process in the early stages of new product development. Birou and Fawcett (1994) found that nature of relationship between supplier and customer firm is important for success of the new product development projects. Mabert et al (1992) found that early involvement of suppliers in the innovation process reduces the development time. Gerwin and Ferrari (2004) through their investigation of several organizational structures found that success of development projects executed through collaboration relies on the various factors such as distribution skills among the partners, newness of the partnership and cooperativeness of the collaboration in the past. Hoegl and Wagner (2005) argues that the quality of working relationship between collaborative partners was dependent on mutual trust, open sharing of information and high project commitment. Wagner and Hoegl (2006) categorized the variables influencing supplier selection into "hard" and "soft" criteria categories. "Hard" criteria involve supplier potential to innovate new products for the customer, and "soft" criteria involves openness, mutual support and reliability between the supplier and the customer firms.

Although much research supports the theory that supplier innovation is beneficial to the new product development performance of a firm, there is some research that suggests supplier innovation might not have a significant positive influence on a firm's product development performance. Littler et al. (1998) through their study of UK firms in communication sector concluded that the involvement of suppliers increases the cost of product as the complexity involved in the management of collaborative projects increases. Also, Hartley et al. (1997) found that supplier involvement in the innovation process was not a significant factor. Supplier involvement was found to have a negative effect on innovation due to the differences in organizational culture. As the differentiation among the firms involved in new product

development increases, challenges to achieving common goals also increase (Susman and Ray, 1999). A major obstacle for supplier integration comes from unwillingness to share the internal design information and "not invented here" culture which prevents engineers from relinquishing product development responsibilities to suppliers (Ragatz et al., 2002). Johnson (1999) emphasizes the need for the implementation of standard procedures to involve suppliers in new product development processes.

Rapid generation of new technology creates technology turbulence in the business environment in which the firms operate. Technology turbulence reduces the life cycle of the product as new products with new technology emerge at faster rate (Tushman and Anderson 1986). Even the firms with higher market share can be squeezed out from the market if they don't acknowledge technology turbulence and take pre-emptive measures (Li and Calantone 1998). The firms should increase research and development activities and create advanced products from the new technologies to capture market and to retain competitive position (Milling et al., 2000). To cope with challenges created by the technology turbulence, the firms must continuously strive to introduce new products at faster rate to sustain competitive advantage (Pisano, 1997). Adopting supplier innovation strategy can reduce the development time of the product as the suppliers are more knowledgeable about their products which enable the manufacturer to release new products to sustain competitive advantage. By utilizing supplier innovation strategy, manufacturers can invest more resources in developing the core competency while outsourcing the innovation activities related to non-core competency. Wagner (2009) proposed the concept of downstream customer orientation of the suppliers in which suppliers acknowledge the needs of the focal firm's customers to innovate the product. Downstream customer orientation of the supplier improves the performance of the new product development (wagner 2009).

Following our review of literature we categorized the variables influencing supplier innovation into the following categories: environmental characteristics; supplier attributes; product characteristics; quality and management of relationship; and duration of partnership. The categorization of prior supplier innovation according to this typology is shown in Table 1.

Table 1: Classification of characteristics for the supplier involvement in the new product development.

Category	Variable Investigated in Prior Studies
Firm Characteristics	⅄ Willingness to accept external ideas
Nature of Enterprise Supplier Relationship	⅄ Role of the supplier (Clark) and enterprise ⅄ Supplier's responsibility ⅄ Frequency of communications (Wasti and Liker) ⅄ Nature of relationship (what aspect?) Birou and Fawcett (1994) ⅄ Newness of partnership - Gerwin and Ferrari (2004) ⅄ Distribution skills - Gerwin and Ferrari (2004) ⅄ Degree of differentiation (sushman and ray) ⅄ Coordination (Gerwin 2004 ⅄ Timing for the involvement of suppliers (wasti and liker 1997)
Supplier Characteristics	⅄ Uniqueness (Park et al. 2010) ⅄ Technical expertise ⅄ Innovativeness (wagner hoegl 2006) ⅄ Component and architectural knowledge (Henderson ⅄ Supplier support to competitors (Frederik et al ⅄ Downstream customer orientation(Wagner 2009) ⅄ Trust and reliability (wagner hoegl 2006) ⅄ Supplier Innovation rate
Business Environment	⅄ Technology Turbulence (Tushman et al 1986) ⅄ Number of suppliers (swan et al
Product Characteristics	⅄ Integral product ⅄ Modular design (Schrader & Göpfert, 1997 ⅄ Number of modules ⅄ Product Dynamism (Swan et al 2003)

In this paper we investigate the influence of supplier innovation under factors like technology turbulence, number of suppliers per product modules (nature of enterprise supplier relationship), technology assimilation capability of suppliers (supplier characteristics), firm (firm characteristics), and competitor (business environment).

PROBLEM STATEMENT

From our analysis of prior literature, with particular focus on prior research on supplier innovation modeling by Park and Oduntan (2010), we identified certain factors, such as, technology turbulence, number of suppliers per module, the rate of supplier innovation

capability, and the supplier's capability to leverage acquired technology as potential factors affecting product performance and long-term competitive performance of firms. The following research questions were proposed to investigate the significance of these factors on a firm's product innovation and long-term competitive performance.

Research Question 1 (Q1)
How do the characteristics of the business environment influence the ability of a firm to effectively leverage the innovation of its suppliers to increase its own innovation performance.

Research Question 2 (Q2)
How does the selection of a sourcing strategy, especially the use of multiple suppliers per product module, affect the ability of a firm to leverage the innovation capabilities of its supplier's in improving its long-term product development performance.

Research Question 3 (Q3)
Is the technology acquisition capability of a supplier a significant contributing factor to the new product development performance of a firm?

The following hypotheses (*H1*)was proposed to investigate *Q1*:

Hypothesis (H1): A firm utilizing a supplier collaboration strategy in a business environment with turbulence will experience higher perceived quality, market share and viability than a firm that does not utilize a supplier collaboration strategy in the similar high turbulence environment.

Hypothesis 2 (H2): A firm utilizing a supplier collaboration strategy in conjunction with a sourcing strategy utilizing with more suppliers per product module will experience higher new product performance, than a firm utilizing a supplier collaboration strategy combined with a sourcing strategy emphasizing fewer suppliers per product module.

The argument behind *H2* is that in a business environment in which technology is rapidly changing, technology investment risk can be mitigated by spreading the risk over multiple suppliers as opposed to focusing the risk on fewer suppliers.

Our final hypothesis was formulated to answer the third research question which was to determine the influence of supplier's abilities to assimilate new technology from the business environment the new product development performance of a firm.

Hypothesis 3: A firm utilizing suppliers with a higher rate of technology assimilation from its environment will have higher higher new product development performance than a firm utilizing suppliers with lower technology assimilation rates.

METHODOLOGY

Enterprise viability model (EVM) which was developed by Park and Oduntan (2010) was used to evaluate each supplier factor to determine its effect of product performance. EVM was developed using agent based modeling technique in which agents were created to represent each entity in the business environment. In each of the simulation experiment, one agent representing the focal enterprise and ten agents to represent competitors were created to simulate the business environment. All the enterprise agents were competing for the demand generated by a small sample 1000 customer agents. All the simulation experiments were designed to be of non terminating in nature. In order to investigate the long term performance of the system, non terminating simulation were used (Kelton). The experimental setup utilized by Park and Oduntan (2010), which utilized a run length of 7,200 ticks was determined to provide sufficient time for the simulation to attain a steady-state. At the end point of each run (of 7,200 ticks) data was collected for each of the response variables. Each of the viability scenarios was performed with 60 replications for each factorial point. EVM was modeled using Repast agent modeling toolkit. Various scenarios were created to generate data to test each of the hypotheses. A firm's product development performance was measured by the perceived quality of its product, its market share and viability at the end of the simulation. The viability of a system can be defined as its ability to maintain functional persistence in its environment (Truszkowski and Karlin 2000). Oduntan (2008) defined the viability as the probability of survival of the focus enterprise, where survival is measured by the firm's market share having a value greater than zero at the end of simulation. Table 2 lists all the variables and their description in the enterprise viability model

Table 2: Variables used in the EVM framework.

Variables	Description	Values
Independent Variables		
Use supplier Collaboration	Indicates whether the focal enterprise engages in supplier collaboration	True/False
Moderating Variables		
Technology turbulence	The rate of technology change in the market over a given time period	Low turbulence / Medium turbulence/ High turbulence
Number of suppliers	Number of suppliers per product module available to innovate	3/7/9/11
Number of product modules	Number of modules that product constitute	Low /medium
TechAcquisitionSuccessinaYear	Capability of the to acquire technology that was developed by the external entities in the industry	Low/medium/high
SupplierRatioofProductReleaseFrequency	Indicates the speed of innovation of the product by the suppliers	0.34/ 0.67/ 1.0/ 1.34/ 1.67
Response Variables		
Perceived quality	The customer's belief about the levels of utility for attributes of the product made by the focal company	
Market share	The market share of the focus company at the end of the simulation	
Viability	The probability of survival of the focus enterprise at the end of the simulation, where its survival is defined as it having a market share greater than zero at the end of the simulation(Od	

All the simulation experiments were subjected to the following assumptions proposed by Park and Oduntan (2010).

- The focus enterprise and the competitor enterprises were all introduced into the market at the beginning of the simulation, and began advertising to customers and developing products immediately.
- There is no restriction on competition between the focus enterprise and any of the competitor agents.
- Other than a seed amount to begin the simulation, all resources for product innovation and advertising came from sales to the customer agents.
- All resources owned by the focus enterprise or its competitor enterprises were invested either in advertising or product innovation.
- All customer agents could equally be reached by the advertising of the focus enterprise and the competitor agents.

- A customer agent had the resources to purchase a product whenever it had a demand for it.
- The customer agents did not incur any switching cost or penalty for switching from one product to another.

RESULTS AND DISCUSSION

The results of each experiment were analyzed using the following steps:

1. ANOVA tests were performed to determine the significance of the characteristics related to suppliers, product and business environment through supplier involvement in the new product development on market share and perceived quality of the focus firm.
2. Logistic regression tests were performed to determine the influence of the variables associated with product characteristics, business environment, and supplier traits through supplier involvement in the new product development on the probability of survival of the focus firm.

All ANOVA and logistics regression tests were performed using the statistical software package Minitab 16.0.

Hypothesis 1(H1): A firm utilizing a supplier collaboration strategy in a business environment with turbulence will experience higher perceived quality, market share and viability than a firm that does not utilize a supplier collaboration strategy in the similar high turbulence environment

From ANOVA results we observe that use of supplier collaboration in the innovation of the product has the highest significant (0) effect under all the three levels of technology turbulence on the market share of the focus enterprise.

Table 3: ANOVA: Influence of Supplier Collaboration on Firm Perceived quality firm under low tech turbulence.

Source of Variance	SS	DF	MS	F
Use of supplier collaboration	0.80467	1	0.80467	205.82***
Error	0.46132	118	0.00391	
Total	**1.26599**	**119**		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

Table 4: ANOVA: Influence of Supplier Collaboration on Firm Perceived quality firm under medium tech turbulence.

Source of Variance	SS	DF	MS	F
Use of supplier collaboration	0.61790	1	0.61790	149.96***
Error	0.48621	118	0.00412	
Total	**1.10411**	**119**		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

Table 5: ANOVA: Influence of Supplier Collaboration on Firm Perceived quality firm under high tech turbulence.

Source of Variance	SS	DF	MS	F
Use of supplier collaboration	0.77507	1	0.77507	197.37***
Error	0.46339	118	0.00393	
Total	**1.23846**	**119**		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

From the above results the use of supplier collaboration has significant effect on the perceived quality of the products produced by the focus firm under all the levels of tech turbulence. Logistic regression model was formulated to assess the influence of the use of supplier collaboration on the viability of the focal firm.

Supplier collaboration is a binary variable in which the value of 1 indicates the use of supplier collaboration and 0 for using supplier collaboration. The results of fitting the logistic regression to the model *(a)* are shown below Table 6.

Table 6: Logistics Regression: Influence of Supplier Collaboration on Firm Viability under low tech turbulence.

Source of Variance	Coefficient	Standard Error	Z Value	Pr(>|z|)
Intercept	-2.9790	0.467099	-5.13	0.00***
Use of supplier collaboration	5.34233	0.754360	7.08	0.00***
*** = significant at 0; ** = significant at .01, * = significant at .05				

The results indicate that the use of supplier collaboration is highly significant to the viability of a firm. Through substitution we get the ratio of the probability of survival of the firm with the use of supplier collaboration to that of the firm without the use of supplier collaboration under low tech turbulence is *4.21* which implies that viability of the firm increases by an order of 4 with the use of supplier collaboration.

Table 7: Logistics Regression: Influence of Supplier Collaboration on Firm Viability under medium tech turbulence.

Source of Variance	Coefficient	Standard Error	Z Value	Pr(>|z|)
Intercept	-1.18958	0.305234	-3.90	0.00***
Use of supplier collaboration	5.2	1.05362	5.00	0.00***
*** = significant at 0; ** = significant at .01, * = significant at .05				

The ratio of probability of survival of the firm with the use of supplier collaboration to that of the firm without the use of supplier collaboration under medium tech turbulence is *4.2*.

Table 7: Logistics Regression: Influence of Supplier Collaboration on Firm Viability under high tech turbulence.

Source of Variance	Coefficient	Standard Error	Z Value	Pr(>|z|)
Intercept	-1.38629	0.322749	-4.30	0.00***
Use of supplier collaboration	5.46388	1.05883	5.16	0.00***
*** = significant at 0; ** = significant at .01, * = significant at .05				

The ratio of probability of survival of a firm utilizing supplier collaboration compared to that of a firm without the use of supplier collaboration under medium tech turbulence is *4.91*.

The above results support hypothesis *H1*, which states that the use of supplier collaboration under technology turbulence influences the market share, perceived quality and viability of the focal firm. Due to technology turbulence, the product life cycle of the new products decrease (Tushman and Anderon 1986). In order to cope up with the reduction of life cycle of the new product, supplier collabaoration can be used as competitive strategy to reduce the development time of the new products (Mabert et al 1992) which can help to increase the product release frequency.

Hypothesis 2 (H2): A firm utilizing a supplier collaboration strategy in conjunction with a sourcing strategy utilizing with more suppliers per product module will experience higher new product performance, than a firm utilizing a supplier collaboration strategy combined with a sourcing strategy emphasizing fewer suppliers per product module.

The influence of number of suppliers available to innovate each type of supplied product modules, on the firm perceived quality, market share, and viability of a firm is evaluated in the following experiment, where the number of suppliers per product module is varied between 7, 9 and 11, and the use of supplier collaboration is also varied bewteen the value TRUE and FALSE.

Table 8 ANOVA: Influence of Number of Suppliers available to innovate on Firm market share

Source of Variance	SS	DF	MS	F
SupplierTechAcquistion	0.2355	1	0.2355	2.06
Number of suppliers	0.0506	2	0.0253	0.22
CompetitorTechAcquisition	2.8478	1	2.8478	24.89***
Error	81.8141	715	0.1144	
Total	**84.9480**	**719**		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

Table 9 ANOVA: Influence of Number of Suppliers available to innovate on Firm perceived quality

Source of Variance	SS	DF	MS	F
SupplierTechAcquistion	0.00172	1	0.00172	0.16
Number of suppliers	0.05348	2	0.02674	2.42
CompetitorTechAcquisition	0.30713	1	0.30713	27.81***
Error	7.89637	715	0.01104	
Total	**8.25870**	**719**		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

Table 10: Logistics Regression: Influence of Number of Supplies available to innovate on Firm Viability

Source of Variance	Coefficient	Standard Error	Z Value	Pr(>|z|)
Intercept	2.24868	0.571423	3.94	0.00***
SupplierTechAcquistion	-0.307908	0.320582	-0.96	0.337
Number of suppliers	0.0000000	0.0490620	0.00	1.000
CompetitorTechAcquisition	-1.80553	0.323736	-5.58	0.000***
*** = significant at 0; ** = significant at .01, * = significant at .05				

From the above results we observe that there is no influence of number of suppliers available to innovate each of the product modules on the market share, perceived quality and viability of the firm through the use of supplier collaboration.. This can be attributed to increase in coordination efforts for collaboration and selection of suppliers becomes complex as the number of suppliers increase *(Zirger and Hartley 1996).*The overhead cost of managing more number of collaborations increase and it is difficult to control the product development as the number of suppliers increase.(littler 1995). The competitor technology acquisition capability is highly significant. As the capability of its competitor to assimilating technology increases, the

market share, perceived quality and viability of a firm reduces due to release of technologically advanced products by the competitor which are more appealing to the customer, and a winning of market away from the firm.

Hypothesis 3 (H3): A firm utilizing suppliers with a higher rate of technology assimilation from its environment will have higher higher new product development performance than a firm utilizing suppliers with lower technology assimilation rates.

The influence of technology assimilation by suppliers on the market share, perceived quality and viability of a firm is tested by simulation experiment in which the variable tech assimilation success in a year for the supplier firm, competitor firm and focus firm takes values 0.1, 0.4, 0.8 and the use of supplier collaboration takes values TRUE and FALSE.

Table 11 ANOVA: Influence of technology acquisition on firm market share.

Source	**DF**	**SS**	**MS**	**F**
CompetitiorTechAcquisition	2	73.819	36.91	354.89***
Use of supplier collaboration	1	262.65	262.65	2525.4***
Focus enterpriseTechAcquisition	2	2.359	1.179	11.34***
SupplierTechAcquisition	2	0.353	0.176	1.7
CompetitiorTechAcquisition * Use of supplier collaboration	2	67.481	33.741	324.43***
CompetitiorTechAcquisition * Focus enterpriseTechAcquisition	4	0.068	0.017	0.16
CompetitiorTechAcquisitio* SupplierTechAcquisition	4	0.084	0.021	0.2
Use of supplier collaboration * Focus enterpriseTechAcquisition	2	0.008	0.004	0.04
Use of supplier collaboration * SupplierTechAcquisition	2	0.047	0.024	0.23
Focus enterpriseTechAcquisition * SupplierTechAcquisition	4	0.759	0.19	1.83
Error	5374	558.904	0.104	
Total	**5399**	**966.533**		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

Table 12 ANOVA: Influence of technology acquisition on firm perceived quality.

Source	DF	Seq SS	Adj MS	F
CompetitiorTechAcquisition	2	0.64327	0.32163	46.34***
Use of supplier collaboration	1	16.96026	16.96026	2443.64***
Focus enterpriseTechAcquisition	2	0.17088	0.08544	12.31***
SupplierTechAcquisition	2	0.00079	0.0004	0.06
CompetitiorTechAcquisition * Use of supplier collaboration	2	0.52893	0.26446	38.1***
CompetitiorTechAcquisition * Focus enterpriseTechAcquisition	4	0.03224	0.00806	1.16
CompetitiorTechAcquisitio* SupplierTechAcquisition	4	0.00925	0.00231	0.33
Use of supplier collaboration * Focus enterpriseTechAcquisition	2	0.01549	0.00774	1.12
Use of supplier collaboration * SupplierTechAcquisition	2	0.01102	0.00551	0.79
Focus enterpriseTechAcquisition * SupplierTechAcquisition	4	0.02421	0.00605	0.87
Error	5374	37.29862	0.00694	
Total	5399	55.69495		
*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05				

Table 13: Logistics Regression: Influence of technology acquisition on firm Viability.

Source	Coefficient	Standard Error	Z Value	Pr(>|z|)
Constant	0.208799	-1.43986	-6.9***	0
CompetitiorTechAcquisition	0.359802	-0.485169	-1.35	0.178
Use of supplier collaboration	0.287916	5.4807	19.04***	0
Focus enterpriseTechAcquisition	0.330147	0.973277	2.95^	0.003
SupplierTechAcquisition	0.341536	-0.0213323	-0.06	0.95
CompetitiorTechAcquisition * Use of supplier collaboration	0.342245	-3.33762	-9.75***	0
CompetitiorTechAcquisition * Focus enterpriseTechAcquisition	0.498744	-0.0653052	-0.13	0.896
CompetitiorTechAcquisitio* SupplierTechAcquisition	0.499291	0.115863	0.23	0.816
Use of supplier collaboration * Focus enterpriseTechAcquisition	0.315159	-0.534353	-1.7	0.09
Use of supplier collaboration * SupplierTechAcquisition	0.31651	0.369982	1.17	0.242
Focus enterpriseTechAcquisition * SupplierTechAcquisition	0.468164	-0.0743542	-0.16	0.874

*** = significant at 0; ** = significant at .001, * = significant at .01, ^= significant at .05

From the above results we observe that the use of supplier innovation, technology assimilation capability of the suppliers, firm, and competitors are significant factors on the market share and perceived quality of a firm. As the technology assimilation capability of its competitor increases, the market share and perceived quality of the firm decrease due to the inability of the firm to develop sufficiently attractive products as compared to its competitors. As the technology assimilation capability of a firm increases, the market share and perceived quality of the firm increases due to its ability to develop products using acquired technology. Interestingly there is significant interaction between the use of supplier innovation and competitor technology assimilation. From the results we argue that supplier innovation can be used as a strategy to compete with competitors who are capable of assimilating technology at high rate.

CONCLUSION

In our research of literature we categorized the variables and characteristics associated with the involvement of supplier in the new product development. In our experiments we investigated the influence of the following factors, use of supplier innovation, number of suppliers per module, technology assimilation capabilities, and technology turbulence on the long-term product development performance of a firm. From our experiments we found that sourcing from more suppliers to reduce technology risk has no influence on the performance of a focus firm. Our research suggests that supplier innovation can be utilized as competitive strategy to cope up with technology turbulence, and to reduce the development time of the product thereby retaining the competitive position in the industry. Under the conditions of technological turbulence in the business environment, costs and risk involved in new development can be shared between the suppliers by using supplier innovation strategy. The ability of a firm and its suppliers to assimilate available technologies in their environment was found to be a highly significant contributor to long-term product development performance, perceive quality, market share, and viability of a firm.

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COHERENCE IN CONTROL OF INFORMATION SECURITY (COINS)

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ABSTRACT

The paper content is based on experiences from a study Feb. 2008 to Jan. 2011 on aspects how to implement (IPL) the information security (ISC) management (MGT) system standard (ISMS) objectives for Swedish governmental agencies' organizations. The following legend – being written contemporarily but independently of the study's final report – based on this author's experienced interpretation of meaning (MNG) and relevance – expressed through syntaxes (STX) the ISMS A5 … A15 control (CTR) objectives (OBJ). The acronyms sign intentions to be operationally (OPE) effectuated (ECT): The paper title associates with 'COINS' for efficient (EFY) use of available (ABY) funds for effective (ECT) abilities. Hence, abilities become treated as real assets (AST) to be authorized (ATH) for an enterprise's (EPR) principal executive (EXE) entity's (ETY) mission intentions as quality of service (QoS) performer. Then, the provider – customer 'conditional statement' relations being noted as [P|Q] about necessary/accompanied attributes or realities/imaginaries or affects/effects. Realities are measurable and hence easier for a provider (P) to get pay or credit for in mission transactions. But, to identify (IDY) realities it is often difficult, even for a QoS questioning (Q) part. The difficulties have its roots in more or less strength (STR), opportunity (OPU), weakness (WEK) or threatening (TRT) environmental events (EVT), culture, (CLT) ethic (ETH), laws or rules (LAW) and objectives (OBJ). The meanings (MNG) have to be messaged (MSG) in technical data communication (DCT) sessions about the OBJ realities; i.e., what QoS realties have to be effected (ECT) in when, where, by whom, how and why contexts (CXT). This is what the communicative information (INF) life cycle processes (LCP) deal with: Achieving ECT to get credit for in sustainable socio-technical (SoT) trustworthy Human Right (HUR) emphasizing relations for safety (SAF). Security (SEC) is treated as an achieved dependable SAF state through EFY in efforts to achieve keyword OBJ MNG ECT.

Keywords: Audit, Authorization, Cognition, Dependability, Account.

PRESUPPOSITIONS

Coherence Conditions

Any molecular or atomic entity (ETY) organization, as a firm enterprise (EPR), needs adaptivity (APT) to organismic environmental events (EVT) through strength (STR) and opportunity (OPY) abilities to compensate weaknesses (WEK) against threat (TRT) in principal/ agent mind to mind communication (COM) relations.

The EPR strategy (STY) ought be toward confidence (COF), integrity (ITY) and availability (ABY) in dependable (DPY) behavior (BEH); i.e., a manageable (MGT) variety in the ETY

quality of service (QoS) abilities as assets (AST) for the life cycle mission performances (LCP), through dependable (DPY) information safety (SAF) protection (PRT) of which rely on, by public accessible (ACS), meaning (MNG) and effect (ECT) in the relational syntaxes (STX). The operational (OPE) action (Act) occurrences (OCU) have to be monitored (MTR) and accounted (ACT) per ETY identity (ETY_IDY). These ACTs together with observation of the EPR relevant environmental (EVM) events (EVT) constitute the audit (AUD) process of the EPR LCP BEH.

The Aim is to Emphasize Enterprise Realities

In this paper, study results in general are treated as enforced or gained knowledge (KNW) being imaginary affections in participating human's minds. The paper content is based on KNW from a study Feb. 2008 to Jan. 2011 for conditions for implementing (IPL) the information security (ISC) management (MGT) system standard (ISMS; ISO/IEC 27001) into Swedish governmental agencies' organizations (EPR ORG). But the KNW has – through experienced perceivers' (PCV) contextual (CXT) experience – to, through KNW MGT, be communicated (COM) for cognition (COG) of the actual enterprise's (EPR) unique realties. The study value (VUE) is dependent on systems' thinking (Lawson, 2010) abilities as assets (AST); i.e., practitioners as real VUE producers.

The Reason

The reason for the study was the Swedish National Audit Organization (SE-NAO) report (RiR 2007:10) about how – relatively to the ISMS – ISC MGT is IPL and maintained (MIT) in a number of agencies in Sweden. On basis of the report, the government directed the Swedish Civil Contingencies Agency (MSB) to take initiatives for ISMS' IPL. The study began – thanks to competitive access to MSB funds – with the money associating 'Communication of Information Security COINS' approach, of which has been reported as 'Controlled Information Security, COINS' (Yngstrom & al 2009a, b) associating with the ISMS' controls (CTR) A5 … A15.

Now, in the paper's title 'coherence' prefix is to emphasize that CTRs rest on, and are for communication (COM) effects (ECT) in general of which are on some way related with a firm's or an agency's economical benefit; i.e., flow of COINS through effectiveness in management of bit carried messages (MSG).

Acronyms and Figures Emphasize Operational Effect Achievement Importance

Acronyms and Figures in the paper are for signaling intentions to achieve operational (OPE) action (Act) effect (ECT). In the study, agency's Acts are treated as enterprises (EPR) with its communication (COM) architecture (ECA). Supposedly, an EPR has three decision levels;

- EXE-0, the principal, for "what may be" (Odelstad, 2008; p. 5) or "what can be" (V. Renssen, 2008; pp. 14f) knowledge (KNW) or strategy (STY),
- EXE-1 for "what shall be" MGT tactic (TAC), and
- EXE-2 for "what is" operated (OPE).

The “what has been” value (VUE) is KNW by audit (AUD) of environmental events (EVT) and accounted (ACT) occurrences (OCU) of monitored (MTR) entity (ETY) behavior (BEH). But, KNW shall be realized for appropriate effect adjustment in cognition (COG; Yadin, 2007) processes.

This paper about the study is outlined as an enterprise (EPR) of its own example.

STRATEGY

“A new [e.g., information security [ISC] management standard (ISMS)] standard in itself does not solve business [EPR] issues. The main issue is that companies should manage [MGT] their information [INF] in electronic form and as a separate asset [AST]. A standard for the definition of information [INF] is just an enabler for such information management [MGT]. ... “ (V. Renssen, 2008; p. 13)

In the current paper, information (INF) meaning (MNG) is conveyed by messages (MSG) being automatically or manually processed (ADP, MDP). So, INF MGT is an adaptation (APT) of ECA's ADP or MDP; MSGs for i.e., data communication technology (DCT).

Securing of Trustworthiness through Protection of Dependability

Approach

Security (SEC) is an earned state, achieved through evaluated (EAL) protection (PRT) of dependencies (DPY); i.e., PRT of ETY_IDYs as assets (AST) against probable risks (RSK, PCY) in AST's safety (SAF). The ASTs are the abilities of which synergy (SGY) effect (ECT) contributes to the EPR's value (VUE) as QoS performer (PEF). The VUE is created in communication (COM) sessions (PCS) through exchange of messages for meaningful (MNG) effect (ECT); i.e., information SEC (ISC):

- ISC {COF: confidence or confidentiality, ITY: integrity in system behavior (BEH), ABY: asset (AST) ability availability (ABY), AUD: audit of accounts (ACT) of monitored (MTR) action (Act) occurrences (OCU) and observed environmental events (EVT)}.

Strategy for the Study

The strategy (STY) taken for the study – by SU/DSV and Swedish Defense Research Agency (FOI) in corporation – was to classify (CLS) it as a socio-technical (SoT) system to be established and managed in a life cycle period (LCP) as an application (API) to the general system theory (GST) framework. The SoT-system has to be available (ABY) in an evaluated assurance level (EAL) secure (SEC) state most of its LCP time. Its LCP sustainability is conditioned by the SoT system components as assets (AST). The ASTs and their relational attribute's synergy reliabilities (RBY), maintainability (MBY) and adequate maintenance (MIT) in the environment (EVT) situational circumstance contexts (CXT) constitute the dependability (DPY) of the SoT system.

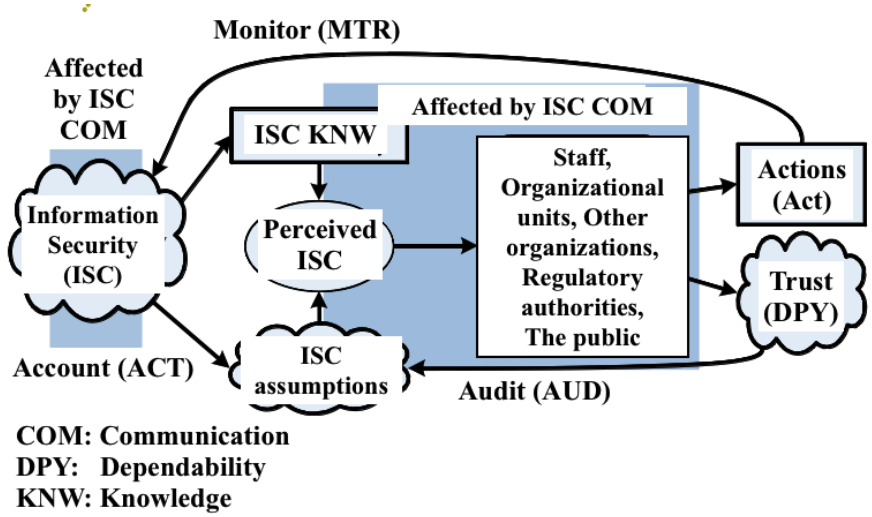


Figure 1: The socio-technical (SoT) system feedbacks (FEB)

DPY is achieved and withheld due the achieved ISMS (ISO/IEC-27001, 2005 Annex A) A5 ... A15 CTR objective ECT and feedback (FEB). FEB is a (Figure 1) three level process;

- monitoring (MTR) operative (OPE) actions (Act) occurrences (OCU),
- accounting (ACT) MTR-data per Act entity identity (ETY_IDY) action (Act), and
- audit (AUD) of ACTs and observed environmental events (EVT).

Cognition as Experienced Knowledge for Conditioning Human Rights Characteristics

Knowledge (KNW) is not enough for dependable Acts. But, it is a prerequisite for how to perceive phenomena and to cognize (COG) what shall be Act because of experienced KNW and hence transform affections to effect (ECT):

1. COG {knowledge (KNW),
2. comprehension (MNG),
3. application (API),
4. analysis SWT for SWOT (strength, weakness, opportunity, threat) of risks (RSK),
5. synthesis (SYN for synergy),
6. Evaluation (EAL)}. (Yadin, 2007; p. 5 adapted)

The MNG of KNW MGT may be an authorization (ATH) of KNW toward COG. Managers have ability and are assets (AST) for doing this. So, KNW may be enough for “can be/have” polices, but COG is necessary for “shall be/have” directives to be “is” in OPE by ATH ETY_IDY-s skill and given access (ACS) to available (ABY) and adequate AST for the contextual (CXT) situation (Monfelt, 2010; Figure 2).

Established Conventions for Coherence

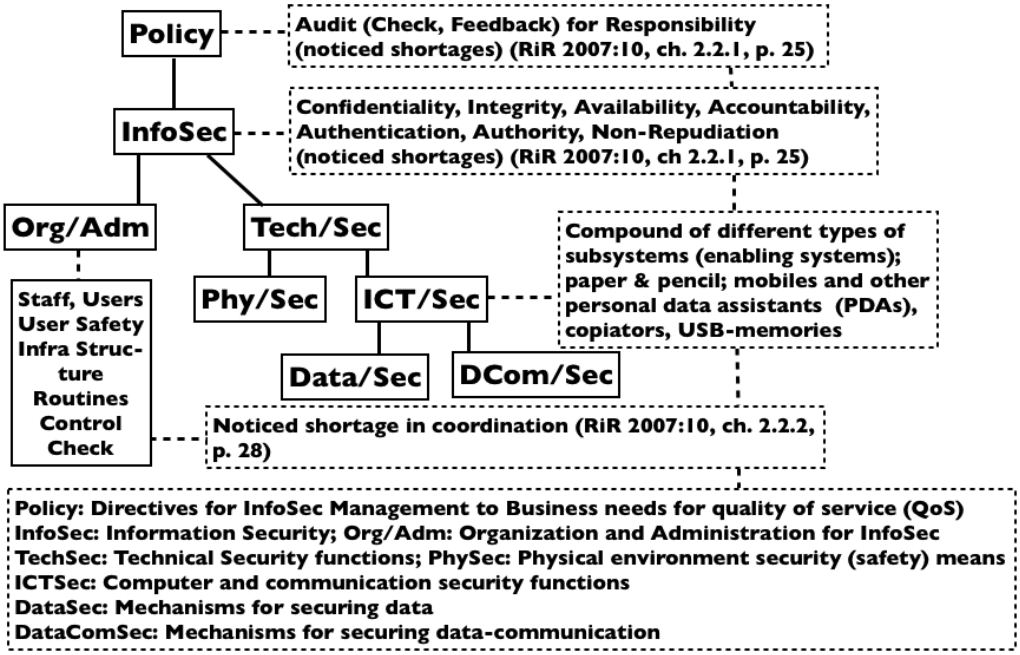


Figure 2: ISC structure (Swedish Standards Institute (SIS) HB550), adapted).

Above Figure 2 hierarchic structure for ISC (InfoSec) is adapted from the handbook (SIS-HB550, 2003). The SNAO report (RiR 2007:10) notifications are identified and classified with respect to the structure hierarchy. But, because the fact that ISC is of global society interest, the used terminology relies on open English dictionaries.

TACTIC

Hierarchy

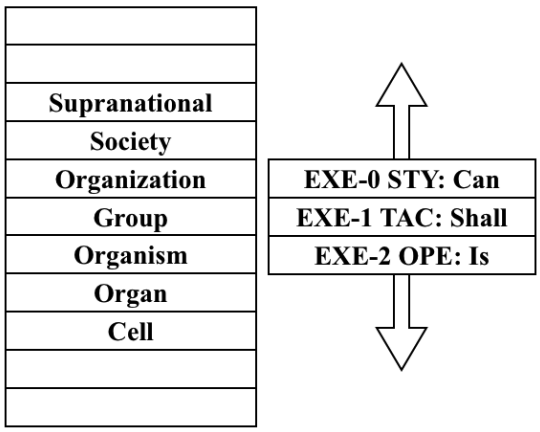


Figure 3: The three level decision hierarchies are relatively to its environment.

The AUD case (Figure 2) can be treated as a society feedback (Figure 3) EVT concerning the agencies as ORG and their PCY being implemented (IPL) and maintained (MIT):

- STY: EXE-0 risk (RSK) policy (PCY) for ISC (InfoSec) with respect to COM partners and environmental EVTs being AUD according to Figure 1.
- TAC: EXE-1 MGT of PCY directives through manually or automatically processed rules (MDP, ADP); i.e. Org/Adm respectively Tech/Sec in Figure 2 to be ACT according to Figure 1.
- OPE: EXE-2 OPE according to MGT rules for Phy/Sec and ICT/Sec in Figure 2 and being

MTR according to Figure 1.

Extension of Figure 1 Content

In Figure 4, the Figure 1 content is reorganized according to the Figure 3 hierarchy. In Figure 4, the 'Staff etc.' in Figure 1 is substituted with the enterprise symbol, EPR {EXE, QoS, ECA, DCT}. 'Message (MSG)' is introduced as a meaning (MNG) conveyor.

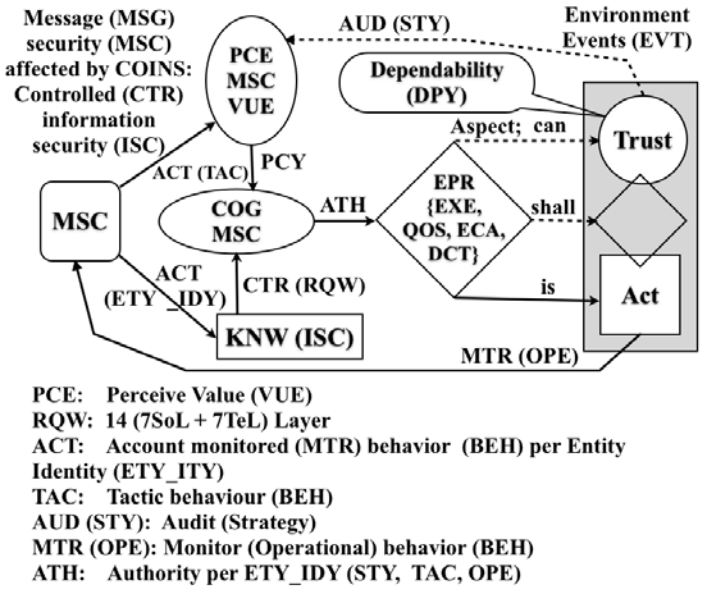
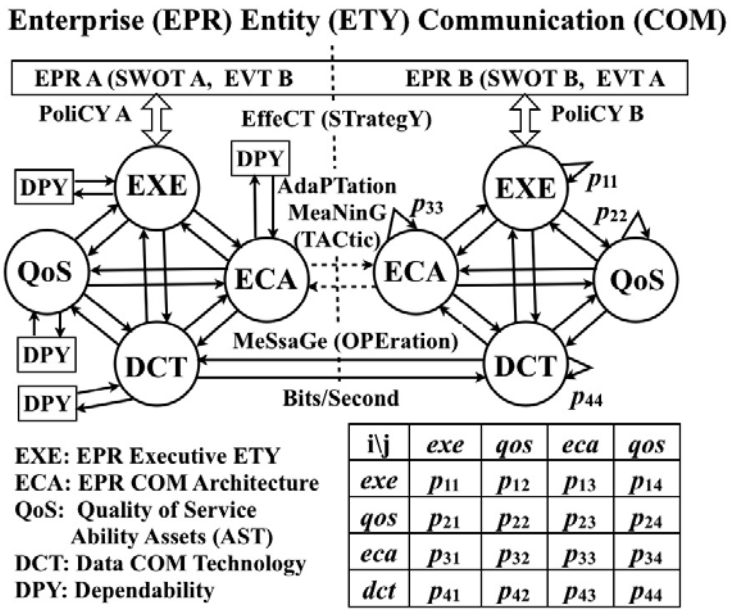


Figure 4: Operationalized Figure 1 for an enterprise, EPR {EXE, QoS, ECA, DCT} and its decision levels STY, TAC and OPE.



i\j	*exe*	*qos*	*eca*	*qos*
exe	p_{11}	p_{12}	p_{13}	p_{14}
qos	p_{21}	p_{22}	p_{23}	p_{24}
eca	p_{31}	p_{32}	p_{33}	p_{34}
dct	p_{41}	p_{42}	p_{43}	p_{44}

Figure 5: The EPR {EXE, QoS, ECA, DCT}

The Enterprise Communication Model

In Figure 5 (Monfelt, 2010; Figure 1, adapted), the left part ii-states are substituted by dependability (DPY; ibid, Figure 3) and the principles for hidden Markov models (More, 2003) for emphasizing DPY of each system component participating as ETY_IDY AST in the system as whole MTR behavior (BEH). The three decision levels are represented by;

- EXE for the EPR EXE-0 “can be KNW” STY,
- ECA and QoS for EXE-1 “shall be COG” TAC, and
- DCT for EXE-2 “is COG” OPE.

An Enterprise Scenario

STY: RSK PCY is conditioned by a ‘can be’ SWOT (SWT) analyzing process of observation, orientation, decision and Act (OODA, Lawson, 2010; Ch. 3) because of environmental events (EVT) as well as accounts (ACT) of monitored (MTR) of OPE Acts.

TAC: STY OODA ‘shall be’ ECA and QoS COM operationalized (OPE) in a plan, do, check and Act (PDCA, Lawson, 2010; Ch. 3) process for rules and directives with respect to ACTs of MTR DCT Acts.

OPE: The PEF according to TAC directives and rules as base for QoS PEF Acts being MTR.

Adaptation for Provider – Questioner Relations

The Communication Situation

The Figure 6 lower part – adaption from Shannon (1948, p. 2) – is about TeL between information source (INF SCE) and destination (INF DST). To INF SCE incoming MSG is encoded (MSG’) to transmitter (TRM) signals (SGN’) of which may be jammed (JAM), distorted or decoyed (DCY) or gathered (SGN INT) before (SIGN’’) to receiver (RCR) for decoding MSG’’ to information destination (INF DST).
An example of messaging archetype is about Web Servi-ces (Booth & al, 2004). Aspects on contents in MSG are in Sjoqvist (2008).

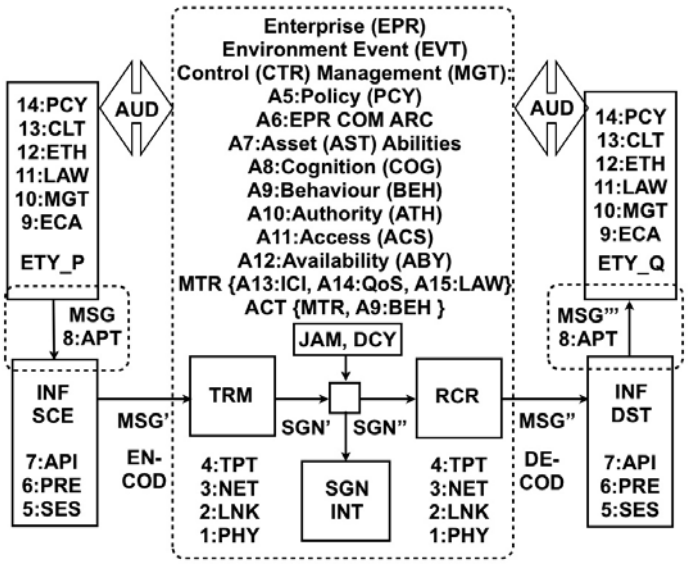


Figure 6: The communication situation (Shannon, 1948; p. 2, adapted).

The DCT 7TeL – open system inter-connection (ITU-X.200, -X.800 OSI) model – 7:applica-tion (API), 6:presentation and 5:session is for peer to peer INF SCE → INF DST actions (Act). In this essay the 7:API is of most interest because of its 8:APT to SoL 9 – 14 (Table 4). TRM → RCR OSI layers are; 4:transport, 3:network, 2:link and 1:physical media.

A Mechanized Analogy for the Communication Situation

In Figure 7 are the Figure 5 states

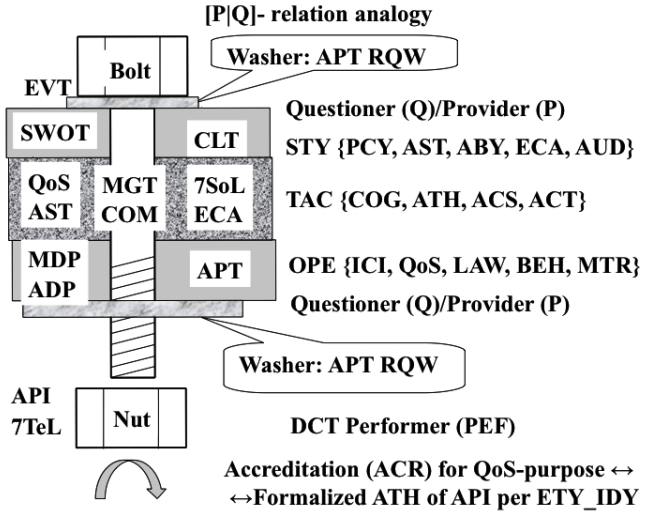


Figure 7: Bolt – Nut analogy of Figures 5 and 6 (idea adapted from Lawson, 2010; p11)

'mechanized'. All of the A5 … A15 ISMS CTR are included and distributed to the three decision levels. The CTRs are specified in Table 1 below. In the decision level (DCL) column, is pointed out which of the CTRs are treated as being of main interest to manage per DCL in correspondence with what is viewed in Figure 6. MTR, ACT and AUD are distinctions of the three level feedbacks (FEB) because of MTR OPE system integrity (ITY) BEH through ICI, QoS and LAW disturbances. The MTR data has to be TAC ACT available for STY AUD.

The two provider (P)/ questioner (Q) relations being marked out in Figure 6 have to be linked: Environmental EVT are Q_{EVT} on STY level to be SWT-RSK analyzed for P_{STY} to serve OPE Q_{OPE} for how to – with respect to eventual ATH asymmetry if another ETY_IDY – response; i.e., P_{OPE} MSG responding the EVT.

Adaptation Situations are Ubiquitous

P→Q situations are ubiquitous; e.g., analogous with principal/agent relations (IEA, 2007, Ch. 1 – 3). Each *P→Q* has to be contextually (CXT) interlinked and hence being APT to each other. If, the APT conditions are peer to peer then [P|Q] relation as viewed in Table 1.

Table 1: Conditional Statement or Modus Tollens or Implication Truth table (Monfelt, 2010; adapted).

P	***Q***	***P→Q***	**SWOT**	**COG Symmetry/Asymmetry**	**Benefit**
T	*T*	*T*	S	Symmetry, [P/Q], peer to peer	Equivalence (↔)
T	*F*	*F*	W	Asymmetry, [P|Q[	P
F	*T*	*T*	O	Asymmetry,]P/Q]	Q
F	*F*	*T*	O/T	Symmetry/ chance/ potentiality,]P|Q[	P or Q (ad hoc, open)

Begin Table 1 *P→Q* example:

"For example the fact P-1001 is [OPE aspect] a part of Process Unit U-1000
This is not 'data', but is an expression of a fact that thus provides information. It expresses semantics. Gellish English enables to express such facts and enables to manage their approval status and history." (V. Renssen, 2008, p. 14)

End Table 1 *P→Q* example.

Aspects of things are in Table 2. (V. Renssen, 2008, pp. 32f.). COINS comment column is inserted.

Table 2: General aspects for '→' (V. Renssen, 2008; pp. 32f.).

IDY	Aspect [STY: can, may be/have, TAC: shall be/have, OPE: is/has]	COINS
1	**Physical object:** Physical objects cover everything that obeys to the laws of physics. For example, a physical object can be an *inanimate physical object*, or an *organization* or a *lifeform* (which has as one of its subtypes *person*). In addition to its normal classification a physical object can also be classified as an *imagined physical object* (e.g. a design) or as a *materialised physical object*. However, in most applications this classification can be eliminated, because it is either clear from the context or can be concluded from the semantics of some relation types. For example, in technical design applications it is a general rule that - Each physical object is an *inanimate physical object*. - Each physical object is an *imaginary physical object*.	ETY
2	**Occurrence:** Occurrences cover everything that happens, such as an act (activity), a process or an event and also a behaviour of a physical object. Occurrences are actually special kinds of relations (interactions between interacting things). Subtypes of the involvement relation specify in what role an object is involved in an occurrence.	EVT OCU BEH
3	**Aspect:** An aspect is something that is possessed by a thing and that characterizes an inherent characteristic of the thing, or is a role that is played by the thing. It can be qualified by a qualitative aspect or it can be quantified.	CTR ASP
4	**Property:** A quantifiable aspect is usually called a property or a physical quantity. A property is typically qualified by a relation to a number on a scale (UoM). [unit of measure]	AST
5	**Quality:** A quality is a non-quantifiable qualification of an object. A quality is typically qualified by a qualitative aspect that is selected from a pick list.	AST QoS
6	**Text:** A text is a string of characters that form a word or a phrase (sequence of words) *or* a numeric value, which can be related to an object as a reference or definition or description (in a context).	MSG
7	**Information** (= **collection of facts**): Information is a collection of facts that can be expressed by a collection of relations. [ibid Figure 37, p. 125]	KNW INF
8	**Organisation:** An organisation can be seen as a structured collection of persons or the design of such a structured collection.	ECA
9	**Person:** A person is an individual life form who can be treated as a physical object, although he or she also possesses spiritual aspects.	ETY IDY
10	**Kind of thing:** A kind of thing (or class) is any subtype of physical object, or occurrence, or aspect, etc.	14L
The above examples are ambiguous if we would not apply the above-mentioned defaults. For example, from the defaults in a technical design context it becomes clear that P-1301 is meant to be a name of a specific imaginary physical object and not about an actual one.		

Control Aspects

An introduction to Table 3 CTR ASP and Table 4 14SoTL:

- The kind of physical object as spiritual person (ETY_IDY) shall (TAC) be authorized (ATH), authenticated (AUT) and adapted (APT) for actions (Act) and messaging (OPE, MSG) in the contexts (CXT) of SoTL14:ETH.

The A5 … A15 controls (Table 3, CTR) are treated as generics for properties; i.e., being metrics

in any $P \rightarrow Q$ for Table 4 14SoTL.

Table 3: A5 ... A15 Controls (CTR; ISO/IEC-27001, 2005; Annex A, adapted).

A	COINS	Control objective aspect	DCL
5	PCY	Policy (PCY) on basis of consensual SWOT/Risk (SWT/RSK) analyzes, by any enterprise executive entity (EXE) how to secure (SEC) mission performance (PRF).	STY
6	ECA	Enterprise Communication Architecture (ECA↮ organization, ORG) about assets (A7:AST) that constitute the enterprise mission performance ability in its organismic sociality (culture (CLT), ethics (ETH), legalities or rules (LAW), management (MGT), operations (OPE) and means.	STY
7	AST	Assets (AST ↔ confidential or confident, COF) means for quality of service (QoS) in mission performance (PEF) communications (COM).	STY
8	COG	Cognition (COG) for ability (AST) to recognize and perceive what enterprise missions are and how to handle these because of the SWOT based A5:RSK PCY.	TAC
9	BEH	Behavior (BEH) dependability (DPY) for entities (ETY).	OPE
10	ATH	Authority (ATH) in parity with an entity identity (ETY_IDY) need of access (A11:ACS) to abilities as QoS assets (A7:AST), cognition (A8:COG) and dependable (DPY) behavior (A9:BEH) and responsibility in parity with the authority (ATH).	TAC
11	ACS	Access (ACS) rights in parity with authority (A10:ATH).	TAC
12	ABY	Availability (ABY) in resources (A7:AST) for dependability (DPY).	STY
13	ICI	Observed incident (ICI) is a first detectable (error = ε>0) signal of change in feed-backed (FEB) performance (PRF) caused by unknown or ignored dependability (DPY) fault (FLT).	OPE
14	QoS	Quality of Service (QoS) account (ACT) is, because of uncorrected error (ERR) of which escalates to a fail (FAL) of which even can be a strength (STR) in mission performance (PRF).	OPE
15	LAW	Compliance (LAW) account (ACT) is policy (A5:PCY = feed forward, meta loop including SWOT) audit (AUD) fail (FAL) or strength (STR) in requisite variety width (RQW) with respect to PCY rules for protection (PRT) of the 14SoT layers.	OPE

The Fourteen Communication Layers to be Controlled

In the '14 layered framework' (Yngstrom & al, 2009; Clarke & al, 2010) adapted in Table 4, the 7TeL associates with the 'Open System Interconnection (OSI)' recommendation (ITU-X.200, 1994) accompanied with (ITU-X.800, 1991) security aspects (ASP). The 7SoL associates mainly with the information system framework (Falkenberg & al, 1998).

Begin Tables 3 and 4 examples:

Table 4 characteristics can or may be/have STY for shall be/have TAC for is/has OPE Table 3 control (CTR) objective (OBJ) for dependable (DPY) QoS mission performance (PEF).

Table 4 14SoT layers represent the complexity variety width. Each ETY_IDY shall have requisite 14SoTL variety width (RQW); i.e., COG in parity with the OPE PEF role to be authorized (ATH) and authenticated (AUT) for adaptation (APT):

- APT {ATH, AUT}
- ATH {ETY_IDY, COG, ACS, AST, DPY (ISC), ACT}

- ISC {COF: confidence or confidentiality, ITY: integrity in system behavior (BEH), ABY: asset ability availability (ABY), AUD: audit of accounts (ACT) or events (EVT)}.

End Tables 3 and 4 example.

Table 4: 7SoL #8 ... #14 + 7TeL #1 ... #7 ↔ 14SoTL (References are noticed).

L#	**COINS**	**Requisite variety width (RQW) 14SoTL characteristics**	**DCL**
14	EVT	Strength, Weakness, Opportunity and Threat based risk policy (RSK PCY) (Flensburg & Kurti, 2007; IEA, 2007).	STY, can, may be
13	CLT	Cultural considerations with Human Right aspects (UN, 1948).	STY, can be
12	ETH	Ethical considerations (V.d. Poel & Goldberg, 2007).	STY, can be
11	LAW	Regulations because of law or PCY including CLT and ETH.	STY/TAC, can/shall be
10	MGT	Management.	TAC, shall be
9	ECA	Organization (ORG); Enterprise Communication Architecture. MNG/ECT	TAC, shall be
8	APT	7TeL (#1 ... #7) adaptation (APT) to 7SoL (#8 ... #14). MSG/MNG (Sjoqvist, 2008)	TAC/OPE, shall be/is
7	API	Applications for messages (MSG). (ITU-X.200, ; ITU-X.800, Booth & al, 2004)	OPE/TAC, is/shall be
6	PRE	Presentation; coding decoding: MSG/Data/Bits.	OPE, Bits, is
5	SES	Session. Chunks of Bits.	OPE, Bits, is
4	TRP	Transport protocol; e.g.; Local network, Internet.	OPE, Bits, is
3	NET	Network.	OPE, Bits, is
2	LNK	Link.	OPE, Bits, is
1	PHY	Physical media.	OPE, Bits, is

Secure Life Cycle States are Ubiquitous for a Sustainable Enterprise

Realizing the Strategic Information Security Approach through Control Management

Table 5 control (CTR) management (MGT) 'shall be' intentions may be implemented in the Figure 8 structure for;

- ISC {COF: confidence or confidentiality, ITY: integrity in system behavior (A9:BEH), A12:ABY: asset (A7:AST) ability availability, AUD: audit of accounts (ACT) of monitored (MTR) action (Act) occurrences (OCU) and observed environmental events (EVT)}.

Table 5: Control (CTR) management (MGT) taxonomy structure.

SoTL (Table 4)	**Control Aspect (Table 3)**	**DCL**
EVT	14SoTL = Requisite Variety Width (RQW); I =i (D, S, t) ↔ I = i (STX, CXT, t) ↔ COG =PCV [ECT (MNG, MSG)]. (Monfelt, 2010; Figure 2)	STY
L14:SWT	AUD {EVT, ACT}	STY
L14:PCY	ISC (A5:PCY) {COF (DPY), ITY (A9:BEH), A12:ABY (A7:AST), ACT}	STY
L10:MGT	ACT {ETY, MTR}	TAC
L9:ECA/ ORG	A10:ATH {ETY_IDY (A6:ECA Role, Need, Right, Responsibility), A8:COG, A11:ACS, A7:AST, DPY (ISC), ACT}	TAC
L10:MGT	Account (ACT) {A13:ICI, A14:QoS, A15:LAW, A9:BEH}	TAC
L10:MGT	APT {AUT (authentic), A10:ATH}	TAC
L8:APT	MTR {A13:ICI, A14:QoS, A15:LAW, A10:ATH}	OPE

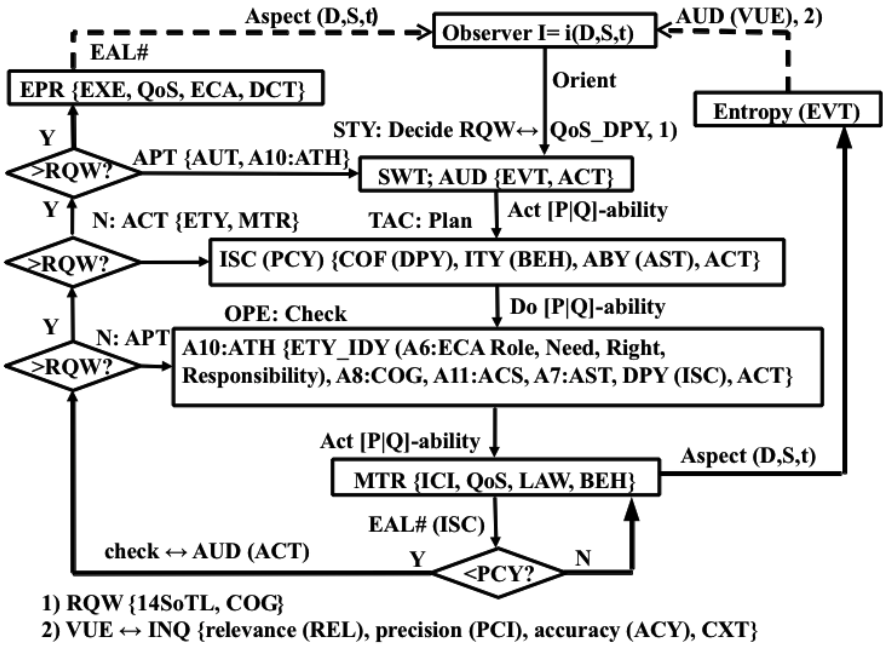


Figure 8: Control (CTR) management (MGT) taxonomy structure (Table 1).

The Table 5 characteristics are structured in Figure 8 with Table 1 *P→Q* conditions in mind:

- INQ: INF quality (Q).
- Observe, Orient, Decide, Act (OODA) and Plan, Do, Check, Act (PDCA) loops interconnection (Lawson, 2010) is utilized.
- Aspect (D, S, t) meaning is: I =i(D, S, t) ↔ COG =PCE(D, S, t) ↔ COG =PCV(MSG) (Monfelt, 2010).
- <PCY meaning is: Check IF OPE MTR(D, S, t) Acts are less than EAL# (ISC) <PCY, THEN APT {AUT, ATH} AND check RQW, ELSE check EVT.
- >RQW meaning is: **IF** the ETY_IDY's MTR Act is greater than its RQW ability **THEN** check the EPR EAL# with respect to EVT, **ELSE** ACT {ETY, MTR} **OR** check the ETY's authenticity **OR** authority: APT {AUT, ATH}.

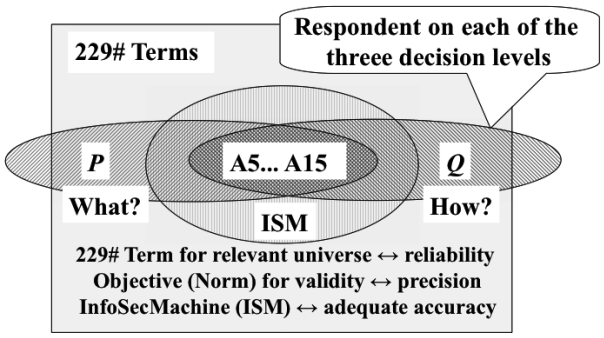
Ubiquitous Frictions in Communications are Security Issues
Figure 9: How do the respondents – in dedicated ISC roles on each of the DCLs – in an agency as EPR, perceive (PCE) the STY propositions (*P*) as PCY “can be“ meaning *Q*s for TAC “shall be” and OPE “is” ECT.

The study approach was taken to investigate how an agency COM about ISC; i.e., how INF is MSG PCE and articulated.

The information system (ISY) in general is defined in the framework (Falkenberg & al, 1998). Supposedly, the general definition is purely for how to create an appropriate ISY for dependable (DPY) mind to mind 7SoL conditioned COM to be developed for and APT for some EPR QoS mission PEF under environmental *P→Q* EVT LCP conditions. The framework is used for selection of the Figure 9's 229 terms or syntaxes (STX), of which COG in some way

contribute to the ISY usability as a 14SoTL COM system.

The Figure 9 evolution is motivated in the study reports (Yngstrom, 2009a, Ch. 5; & 2009b) and is presented in Clarke & al (2010) to be published (Monfelt & al, 2011). The InfoSec Machine (ISC – machine, ISM) symbol in Figure 9, is a mind model to be created by any EPR ETY how to manage its LCP mission PEF as QoS provider. Only ETY of its own – with principal EXE responsibility – is able to COG and CTR its EVT conditioned COM Acts. These are manifested trough CXT {what, when, where, who, how, why} MSG. Then, the basics for COM is to KNW the MSG MNG and, as an ATH OPE Acting ETY_IDY, having ability to COG the ECT thereof (Monfelt, 2010). The ISM purpose is for APT of the audit-able CTR-s to the EPR ETY. A general ISM example (Yngstrom & al, 2009b) is viewed in Figure 9. In Table 5 not A5 … A15 dedicated CTR; e.g., MTR, ACT and AUD are examples of which motivate ISM (Figure 10) as a tool for APT of A5 … A15 to the EPR.



1. ISM is based on the hits among the 229# term set.
2. Objective (Norm) is based on the ISM term hits among the normative A5 … A15 ISMS objectives.
3. *P*: Test (Statements) are an agency's propositions.
   Q: Test (Responses) are respondents (EXE-0, EXE-1, EXE-2) reaction on the pragmatic situation within the agency.

Figure 9: The study approach. (Clarke & al, 2010; adapted)

A DCT (Figure 5), as a 7TeL system component ETY, may be programmed for PEF of MDB or ADB routines. Web services architecture (Booth & al, 2004) in an example of that kind of MSG Acting. In Figure 5 CXT, the part-A's QoS and DCT states interact on EPR B ETY IDY's requests. The ETY_IDY may be satisfied if that kind of relation is acceptable for its CXT situation; i.e., with respect to the 14SoTL RQW. But, the preparation for mechanized interactions is 7SoL COM DPY conditioned:

- The MNG of DCT aided ISY is to effecting (ECT) the wanted QoS CXT VUE efficiently (EFY). For this the DCT→ECA RQW APT DPY has to be CXT maintained (MIT). The Web services architecture (Booth & al, 2004) views an example how to manage 7TeL MSG to be APT for an EPR mission purpose by, or by agents on behalf of, the EPR EXE-0. MSG content aspect principles are examined in Sjoqvist (2008).

OPERATION

The study approach was taken for how an agency as EPR COM about ISC; i.e., how MSG INF MNG is PCE, presented, exposed or articulated for appropriate ECT; i.e., become COG.

PDCA: Plan Do Check and Act the Interview Guide

Plan:
Semi-structured interviews were undertaken at the selected agency using a predefined inter-view guide. The following themes regarding information security issues were covered by the guide (Yngstrom & al, 2009a; Ch. 6 for '*P*' & Ch. 7 for '*Q*'):

Done:

A. Interview of ISY related decision structure to probe if an agency is concerned with focus on QoS COM or on DCT. (Reported in Yngström & al, 2009a; Ch. 5)
B. Interpretation of A5:PCY directives; i.e., '*P*' in Figure 9. (Reported in Yngstrom & al, 2009a; Ch. 6)
C. Interview if one security manager on each of the STY, TAC and OPE decision levels (DCL); i.e., '*Q*' in Figure 9. (Reported in Yngstrom & al, 2009a; Ch. 7).

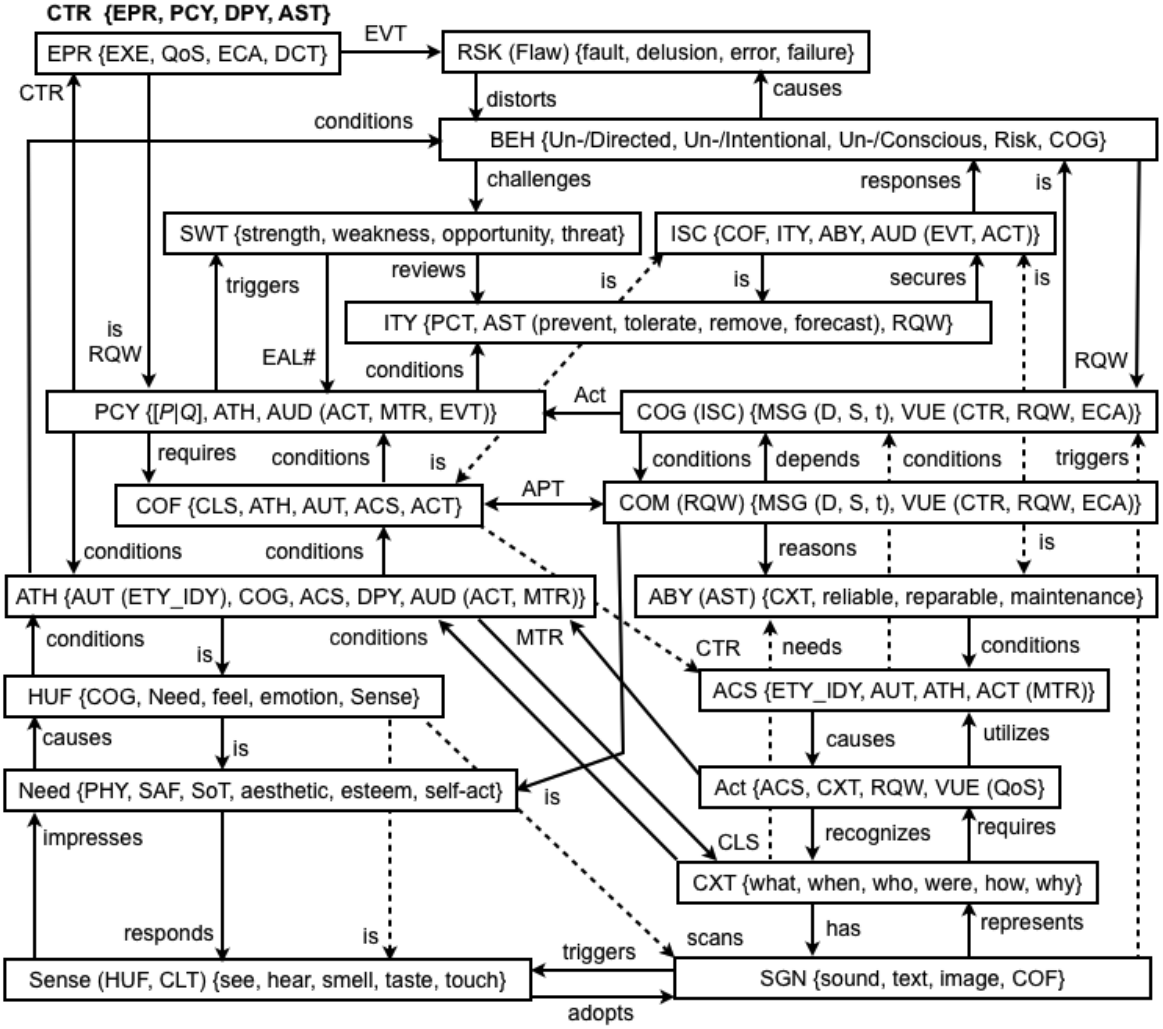


Figure 10: Information Machine (ISM) graph example associates with the EPR (Figure 5) structure (Yngstrom & al, 2009a, b).

Table 6: Interview guide and its use for *P*→*Q*.

'***P***'	**Interview guide aspect (comment)**	'***Q***'
*1	General information security work (EXE-0 STY),	72x
*2	Management information security work (EXE-1, TAC)	73x
*3	Operative information security work (EXE-2, OPE)	74x
*4	Information security needs (L14:RSK, A5:PCY)	75x
*5	Problems and needs for change **('*P*' is not appropriate)**	76x
*6	Information security communication structures (ECA-0, ECA-1, ECA-2)	77x
*7	Assessing information security (DCT or QoS COM focus, **no '*P*'**)	78x
*8	Concepts and terminology (basic for COM of COINS, **no '*P*')**	79

Check:

D. An agency selected for test of the interview guide (Table 6)

Table 7: Compound of interviews for '*Q*' (Yngstrom & al, 2009a; Ch. 7)

Id	Header (Report 7.12-7.19)	ISMS (A5- A15)	ISC-Machine (ISM)	Hits #
721	InfoSec perspectives and associations	Business (enterprise)	Risk (EPR)	36
722	Goals, visions and decisions	Policy (A5)	EXE (PCY)	13
731	Tasks and responsibilities [Authority]	Access (A11)/ Communication (A10)	ACC (ATH) [ACS]	39
732	Consequences of violating InfoSec [Account]	Incident (A13), Business (A14), Compliance (A15)	Risk (ACT)	7
741	InfoSec attitudes [Behavior]	PhySec (A9)	Risk (BEH)	20
742	InfoSec training and information [Cognition]	Human Sec (A8)	Need (COG)	26
751	Access rights, credibility, integrity, secrecy issues	Access (A11)/ Asset (A7)	ACC (AST) [ACS]	49
752	Critical systems [Confidential Assets]	Asset (A7)	AST (QoS)	18
761	Insufficient InfoSec knowledge and training	Human Sec (A8)	Risk (COG)	49
762	Insufficient regulations and policies	Compliance (A15)	Risk (LAW)	6
763	Misuse of data	Asset (A7)	Risk (AST)	4
764	Lack of speed	Incident (A13)	ICI (ACT)	11
765	Inherent structural problems	Organization (A6) [ECA]	Risk (ECA)	19
771	Existing information communication structure	Organization (A6)	Risk (DM)	29
772	InfoSec communication structures	Communication (A10)	ECA (InfoSec)	29
773	Feedback	Incident (A13), Business (A14), Compliance (A15), Policy (A5)	ACT (PCY)	28
774	Other [Observations]	Incident (A13)	ICI (Delay)	14
781	Existing control routines, evaluations and measures	Control (A5- A15)	ACT (Control)	23
782	Difficulties in measuring InfoSec	Incident (A13), Business (A14), Compliance (A15)	ACT (ICI)	13
783	Possibilities for measuring InfoSec	Incident (A13), Business (A14), Compliance (A15)	ACT (QoS)	44
784	Collaboration with other [X0|C0]	Communication (A10)/ Policy (A5)	Risk (PCY)	16
791	Existing concepts and terminology	InfoSyst (A12)/ Asset (A7)	ABY (AST)	17
792	Needs for concepts and terminology	Human Sec (A8)/ Asset (7)	COG (AST)	15
793	Use of concepts	Communication (A10)	ECA (ATH)	18

Acts:

A. Figure 9 Interpretations of '*P*' and '*Q*' related 2008 springtime interviews (Table 7).
B. Reports: Yngstrom & al, 2009a, b.
C. Report: Information security metrics based on organizational models (Hallberg & Lundholm, 2009) describing the three DCL EPR model an analyzing *P*→*Q* aspects in the agency's Figure 7 and Table 6 A5:PCY ↔'*P*' directives (Yngstrom & al, 2009a, Ch. 6).
D. Follow up interviews (Spring 2010).

The Reported Results

Reported (Yngstrom & al, 2009a) results from the Figure 9 principle, are in Table 8. The five uppermost rows with bold text are about the in this paper used model structure. Then the following three pairs of rows are for data; (1) the norm, (2) *Q*, and (3) *P*.

Table 8: X-axis in the COINS' decision structure (Figure 12).

CTR IDY	PCY	AST	ECA	ABY	ATH	COG	ACS	ICI	QoS	LAW	BEH
	A5	A7	A6	A12	A10	A8	A11	A13	A14	A15	A9
P/A	[*P*|*Q*]-relation				Authority (ATH)			Auditing (MTR, ACT, AUD)			
INF	PCV (MNG)				COG (MNG)			MNG (D, s, t)			
EXE	Can Strategy (STY): AUD				Shall Tactic (TAC): ACT			Is Operation (OPE): MTR			
%[1)]	3.7	4.7	4.7	13.1	22.9	11.8	12.1	6.4	5.1	8.8	6.7
EXE[1)]	STY (A5 ... A15): 26.2%				TAC (A5 ... A15): 46.8%			OPE (A5 ... A15): 27.0%			
%[2)]	9.7	5.8	10.1	7.8	15.2	9.9	11.9	8.9	6.6	9.5	4.5
EXE[2)]	STY (*Q*): 33.4				TAC (*Q*): 37.0			OPE (*Q*): 29.5			
%[3)]	7.5	5.2	8.4	10.4	18.2	7.8	16	6.6	5.4	8.6	5.9
EXE[3)]	STY (*P*): 31.5				TAC (*P*): 42.0			OPE (*P*): 26.5			

1) Distribution of the subset terms to the 229 term set (Figure 9) that hit the CTR OBJ A5... A15.

2) Yngstrom & al (2009a; Ch. 7, Table 34)

3) Yngstrom & al (2009a; Ch. 6, Table 6)

OODA: Observations, Orientations, Decisions and Acts

Observations

Table 6, rows *5, *7 and *8 have no '*P*' directive. These facts may indicate probable distinct inbuilt inconsistencies among others as reported in Hallberg & Lundholm (2009):

"... The models show that many interactions within the agency involve entities which are very broadly defined, e.g. "agency personnel". With entities like this in the organizational model it is hard to assign responsibilities for actions connected to these interactions. …" (Hallberg & Lundholm, 2009; Summary)

The above distinct inconsistencies may directly impact aspects in Table 7; i.e., 761 -765, 781 - 784 and 791-793.

Transcript Example 781b:

"781b/ X0: X0 says that there is not systematic process for measuring and evaluation InfoSec activities at the [X0|C0]. However, there are present attempts to control follow up InfoSec matters and to introduce InfoSec measures. Often the internal regulations are used as a measure and different activities are measured against them. Perceived deficiencies are reported to the highest management together with suggestions on how to improve things. The respondent in particular mentions the PDCA-method and is control phase. He hopes this method will provide the [X0|C0] with new tools for controlling and measuring large amounts of information, the "overall picture". But a problem is that the method will not be fully implemented until three years from now." (Yngstrom & al, 2009; Ch. 7.3)

Then, what issues in Table 8 have to be focused on. Notable discrepancies are 'STY' and 'TAC' columns. The reason may coincidence with the above observed inconsistencies.

Orientations
There have been face to face dialogues about the interview transcriptions and presentations in seminar form at fall 2009 and at winter 2010.

Decisions
Within the interviews there were decisions made like that what is noticed in the above 781b example.

Acts
The spring 2010 follow up interviews have the meaning that things are in progress for being better. This is by the current author been noticed for concerning [*P*|*Q*] relations, authorization (ATH) and audit (AUD) with related monitoring (MTR) and account (ACT).

CONCLUSIVE AUDIT

Realize the Strategic and Tactic Approaches through Control Management Taxonomy

Security (SEC) is an earned state, achieved through evaluated (EAL) protection (PRT) of dependencies (DPY); i.e., PRT of ETY_IDYs as assets (AST) against probable risks (RSK, PCY) in AST's safety (SAF). The ASTs are the abilities of which synergy (SGY) effect (ECT) contributes to the EPR's value (VUE) as QoS performer (PEF). The VUE is created in communication (COM) sessions (PCS) through exchange of messages for meaningful (MNG) effect (ECT); i.e., information SEC (ISC) through Table 5 control (CTR) management (MGT) 'shall be' intentions implemented in the Figure 8 structure for;

- ISC {COF: confidence or confidentiality, ITY: integrity in system behavior (A9:BEH), A12:ABY: asset (A7:AST) ability availability, AUD: audit of accounts (ACT) of monitored (MTR) action (Act) occurrences (OCU) and observed environmental events (EVT)}.

Social Life Depends on Mechanism Adaptation

"... [T]he power conferred by technique [DCT, 7TeL] is social [7SoL], not individual; an average individual wrecked on a desert island could have achieved more in the seventeenth century than he could now. Scientific technique requires co-operation of a large number of individuals organized under a single [EXE-0] direction. Its tendency, therefore, is against anarchism and even individualism, since it demands a well knit social [ECA] structure. Unlike religion, it is ethically [ETH] neutral: it assures [EAL] men that they can [STY] perform wonders, but does not tell them what [EPR] wonders to perform [PEF]. In this way it is incomplete. In practice, the purposes to which scientific [OPE] skill will be devoted depend [DPY] largely on chance [SWT]. The men [EXE] at the head of the vast organizations which it necessitates can, within [EVT] limits, turn it this way or that as they [PCY] please. The power [ATH] impulse thus has a [SWT] scope which it never had before. The philosophies that have been inspired by scientific *technique* are power philosophies, and tend to regard everything non human as mere raw material. Ends [LCP] are no longer considered; only the [OPE] skillfulness of the process is valued [VUE]. This also is a form of madness. It is, in our day [1946 > WWII end], the most dangerous form, and the one against which a sane philosophy should provide an antidote. ..." (Russell, 2000, pp. 481f)

Current CXT conclusion:

- APT of each API has to be formally ATH; i.e., DCT /ECA implementations have to be accredited (ACR) and AUD.

[*P*|*Q*] relation

P→*Q* relations are supposed to associate with principal/ agent (P/A) ditto (IEA, 2007). Following citation from the spring 2010 follow up (above OPE PDCA G) interviews exemplifies the situation at the studied agency. The example is related with Tables 6 and 7⁄ 79x (792) example:

"The procurement-delivery [P/A] model is an approach that EXE-0A perceives as a tool for the management process. The respondent, EXE-0A, believe that the provider side has an emphasis on technology, as the work most often regard service and administration (*LCP- maintenance*), that needs to be wrought towards a user perspective. Both respondents on EXE-2 level have a less positive to strongly negative view of the procurement-delivery model. Some of the reasons were that the model was applied to an organization that was not [COG] ready for it (2) and who did not have its communication structures (3) sufficiently clearly drafted. One of the respondents stressed that as the model is unclear within the agency, it will be even more unclear for subordinate agencies (4). This applies mainly to responsibility [ATH] allocation." (Spring 2010 interview)

Authorization

Tables 9, 10 and Figure 11:

- COG {Knowledge, Comprehension, Application, Analysis, Synthesis, Evaluation} (Monfelt, 2010 adaptation from Yadin, 2007 about Bloom's Taxonomy, 1956).

Table 9: The meaning (MNG) of Table 9 states.

i	j	Meaning (MNG) per state i, j
1	1	SoL11-SoL14 for A5:RSK PCY in parity with A7:AST for A14:QoS performance (PEF).
2	1	COG is contextual (CXT) experienced KNW for L9 ↔A6:ECA to be L10 MGT for ATH.
1	2	Uncertainty about what to do for DPY (resilience). May be caused by some kind of social engineering (SOE). Has to be MTR for ACT, AUD and SoL10:MGT towards OPE benefit. The state represents the (i, j) = (i, i) in the EPR Markov chain model (Figure 5).
2	2	OPE actions (Act) to be MTR for ACT purpose.

Table 10: States in Figure 11.

i|j	j=1: Ability (A7:AST)	j=2: Authority (A10:ATH)
i=1: Knowledge (KNW)	Strategy (STY)/Audit (AUD)	SOE/Audit (AUD)
i=2: Cognition (A8:COG)	Tactic (TAC)/Account (ACT)	Operation (OPE)/Monitor (MTR)

Authority (ATH) without ability as asset (AST) is treated as social engineering (SOE) in Table 9, (i, j) = (1, 2). Knowledge (KNW) has to be managed and trained in contextual (CXT) experience for requisite variety width (RQW) cognition (COG) of which is treated as neces-sary for being an available (ABY) ETY_IDY ATH (Table 5) being adapted (APT) for appli-cation (API) operations (OPE) Acts (Figure 11):

- ISC {COF, ITY, ABY, AUD (ACT, MTR)}.

Tables 6 and 7/ 72x and Table 8 example:

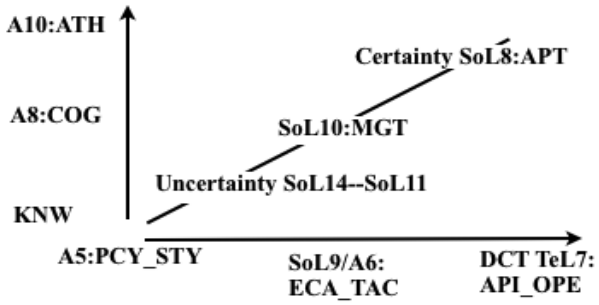


Figure 11: Variety (RQW) management (MGT) (V. Gigch, 1978; p. 381, Fig. 14.2, adapted).

"The EXE-2 respondents complain that management [MGT] does not work properly because of shortcomings in; e.g., (1) feedback, (2) current level of knowledge [KNW, COG], (3) unwilling-ness to allocate resources [abilities as assets (AST)], (4) ability [AST] to communicate [COM].
Regulations for security issues is the means of the management [MGT] to point at violations against the information security policy [PCY] performed, but the main effort by the management is to support organizational business [EPR] both on a daily basis and during incidents [ICI]. Respondents in the EXE-2 level highlights the negative consequences of the managements stubborn persistence on responsibility [ATH] being a management domain only (5) unwillingness to delegation, (6) inability [WEK] to communicate decisions, (7) no consequences at information security violations from the operational personnel or system owners [SOW]. The provider side has no mandate [ATH] to manage enforcement.

Respondent EXE-2K highlight the difficulty to distinguish between different related fields; e.g., (8) security-justice, and thus the responsibility [ATH]. The same respondent also points out that it is easier if you (9) know who in the organization who have responsibilities [ad hoc], be it official or not." (Spring 2010 interview)

Monitor, Account, Audit

Tables 6 and 7/ 72x, 73x, 74x, 79x and Table 8 example:

"All of the respondents know that the [ISMS] standard is a document that the agency is set to follow. They see the document as comprehensive and universal. All respondents believe that it must be adapted [APT] to the organizational [ECA] domain before it can be used. This means that it, in the form it has, can be used as verification of the agency current work, as a checklist of work in progress and as an idea bank / adviser for what can (should) be done." (Spring 2010 interview)

Proposed Structure Model

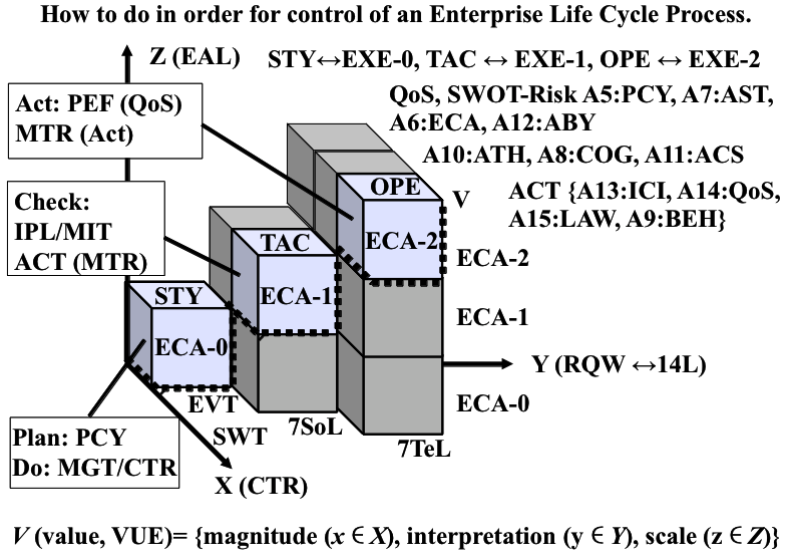


Figure 12: Communication (COM) is a target of evaluation: Z(EAL).

Tables 8 and 10 CTR order is include in Figure 12 of which MSG the idea that the COINS' cube thinking model (Hallberg & Lundholm, 2009) can effective the COM for APT ↔ #8 (14SoTL), because it has to be done for each of the APIs (Monfelt, 2010).
Controls (CTR) have 'can', 'shall' and 'is' aspects on formal authorization (ATH); – accreditation (ACR) – of requisite

variety width (RQW) in QoS performance (PEF) to be monitored (MTR) accounted (ACT) and audited (AUD) relatively to environmental events (EVT).

Using ISM functional operator '○', Figures 8 … 12 ISM may be expressed through:

- ATH (RQW)≈ can (CTR ∩ STY) ○ shall (CTR ∩ TAC) ○ is (CTR ∩ OPE) ↔
- (ATH) RQW≈ EXE-0 (PCY) ○ EXE-1 (ECT) ○ EXE-2 (PEF) ↔
- (ATH) RQW≈ STY (RQW) ○ TAC (RQW) ○ OPE (RQW) ↔
- ATH (RQW) ≈ ATH (RQW_{SWT}) ○ ATH (RQW_{SoL}) ○ ATH (RQW_{TeL})
- V = VUE (COM)≈ ECA-0 (ATH_{SWT}) ○ ECA-1 (ATH_{SoL}) ○ ECA-2 (ATH_{TeL})

A structure for going further with the SoT APT may be found in the Common Evaluation Criteria (CC) protection profile (PP) examples (CCRA, 2005).

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CORRELATION OF ACTORS' RESOURCE-BASES WITH THEIR NETWORKING TENDENCIES - VIEWS ON THE BIOENERGY BUSINESS

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ABSTRACT

In fast-evolving business areas, firms usually need networks to provide them with resources, respect and negotiation power they do not possess on themselves. However, firms should also avoid becoming too entangled in restrictive relationships. The paper examines how actors balance between embeddedness and independency in their relationships, and how this balancing and their willingness and ability to share social capital reflect on the networks they tend to form. Furthermore, the paper discusses the resource-bases of actors, and searches linkages between the actors' resources and their networking tendencies. The paper provides understanding on how independency and associability affect the formation of networks, and how the different resource- palettes of the actors correlate with this network formation. As a case, we study a group of biomass heating enterprises, where four groups with different networking tendencies are recognized and further assessed. The results provide evidence that depending on the set objectives, the actors tend to form different networks which differ from each other by the power relations and the openness of sharing social capital in them. In addition, the actors differ remarkably in their bases of resources, and different aspects are highlighted in their resource- palettes. This creates different motives for cooperation and networking.

Keywords: networking, resources, independency, associability, bioenergy business

INTRODUCTION

There is a global concern about increasing greenhouse gas emissions, and the prices and amount of exhaustion of traditional fossil fuels are continuously increasing. As a consequence, the use of renewable primary energy sources and improved overall energy efficiency play an important role in future energy production and consumption (Cowie & Gardner, 2007; Tekes 2008). One of the most promising options of renewable energy is the utilization of different biomasses. The bioenergy business offers new business opportunities increasingly, to existing actors as well as to the new ones. In addition, as in several other fields of business, also the significance of networking is becoming more evident in the bioenergy production solutions.

Cooperation and networking can provide a valuable source of support and information, as well as means of sharing resources (Fuller-Love and Thomas, 2004). Networks offer access to the assets and capabilities of other actors (Chetty and Wilson, 2003). Especially, emerging actors usually need external networks to provide a variety of resources, capabilities or legitimacy which they would need for successful survival, but which they cannot produce internally (e.g. Hite and Hesterly, 2001; Mei and Nie, 2008). Bioenergy can be characterized as a fast-evolving field offering several kinds of new business opportunities and models, and thus attracting existing as well as emerging actors. For the actors, networking usually offers a reasonable way to exploit new entrepreneurial opportunities or to develop existing ones by sharing resources and capabilities with each other.

The actors should avoid becoming too entangled in restrictive relationships, however (e.g. Staber, 2005), but maintain a certain level of freedom to secure their own interests. In other words, firms should be *embedded* (Granovetter, 1985) and *independent* at the same time (De Wit and Meyer, 2005). In addition, every actor has a certain level of *associability*, which means that they in general differ in terms of sharing social capital, which has an impact on their willingness and the easiness to form partnerships and networks (Leana and Van Buren, 1999).

The aim of the study is to complement the knowledge on the benefits and delimitations of networking with a two-step process. First, we look at the two aspects mentioned above, the actors' independency and associability, and examine the different networking tendencies based on them. Secondly, in order to examine the motives for networking in a fast-evolving business area, we take a look at the resource-bases of the actors, and search linkages between the actors' resources and their networking tendencies.

The research question of the paper is: "How does the resource-base of an actor correlate with its tendency to form networks?" Case study research (e.g. Creswell, 2007; Eriksson and Kovalainen, 2008) is used as the research strategy. The research data has been collected by theme interviews. As the case, we use a group of Finnish biomass heating entrepreneurs which we consider to represent well a group of actors in a fast-evolving business area. The research data consists of 26 semi-structured theme interviews with the biomass heating entrepreneurs and supportive material.

The study confirms that each actor has a certain level of independency and associability, and based on them, a certain tendency to form networks. These tendencies lead to formation of different network types. Among the studied enterprises in the biomass heating field, four groups with different networking tendencies are recognized and further assessed. These groups are: 1) actors in local networks of equal partners, 2) actors with strong relationships with heating plant manufacturers, 3) network developers/lead firms, and 4) independent actors.

In addition, we illustrate that the actors differ remarkably in their bases of resources, and also that different aspects are highlighted in their resource- palettes. This creates different motives for cooperation and networking, which are reflected well in the four networking types found in the studied field. On the basis of the analysis, correlations between the actors' resources and their tendencies to form certain kinds of networks can be found.

BIOMASS HEATING ENTREPRENEURSHIP AND CHP

Heat energy production is mainly considered as a local activity. Wood chips, which are the main fuel in the plants, are typically procured in the surrounding area. In addition, the plants may use supplementary fuels, such as peat, agrobiomass and oil. The heating enterprise may take care of all the steps from fuel procurement to the delivery of heat to real estates or the heating network, as well as the maintenance of the plant, or it may concentrate on the actual business activities of the plant, or something between these (Okkonen and Suhonen, 2010). Typically, a heating entrepreneur or enterprise is a single entrepreneur, an entrepreneur consortium, a company or a cooperative (Okkonen and Suhonen, 2010; TTS 2010). In this study, the terms 'heating entrepreneur' and 'heating enterprise' are used interchangeably, referring to all these possible forms of ownership. In Finland, the number of heating plants operated by heating entrepreneurs was 455 in 2009. The number of heating enterprises was a bit lower, because some enterprises operated in several heating plants. The average size of the plants was 550kW. 90 percent of the solid fuel used in the plants was wood chips (TTS 2010).

As in many other countries, the possibilities for small-scale combined heat and power production (CHP) have been discussed widely in Finland as well, also among the heating entrepreneurs. CHP is a process of producing electricity and usable thermal energy (heat and/or cooling) at high efficiency and near the point of use. CHP contains three elements: simultaneous heat and electricity production, high-efficiency performance, and proximity of the energy production unit to the customers (WADE, 2003). Various technologies using different primary fuels are suitable for CHP production. However, many of small-scale implementations still require significant R&D investments before they are feasible for possible commercialization (Motiva, 2010).

A small-scale bio-CHP could form a supplementary building block for a more sustainable future energy system in many countries. The economical and ecological performance of a small-scale CHP varies by technology and strongly depends on the implementation context.

All in all, regulations and institutional frameworks play a crucial role in the development and diffusion of small-scale bio-CHP technologies (Pehnt et al., 2006).

LITERATURE REVIEW

Networks offer access to the assets and capabilities of other actors (Chetty and Wilson, 2003), and cooperative activities and networking can thus provide a valuable source of support and information as well as means of sharing resources (Fuller-Love and Thomas, 2004). Especially, emerging actors usually need external networks to provide a variety of resources, capabilities or legitimacy which they would need for successful survival, but which they cannot produce internally (e.g. Hite and Hesterly, 2001; Mei and Nie, 2008).

Resources are tangible and intangible assets that a firm controls, and which it can use to conceive and implement its strategies. The capabilities of a firm enable it to take full advantage of its resources, and an individual firm's performance is thus built on its ability to achieve competitive advantage based on its unique resources. The sources for sustainable competitive advantage are resources which fulfill the VRIN-attributes, i.e. they are valuable, rare, inimitable and non-substitutable (Barney, 1991; Barney and Hesterly, 2006).

Thus, an essential component of benefiting from networks is how well the participants can utilize each others' resources, i.e. what are their networking capabilities (Rajala and Westerlund, 2009). But, on the other hand, firms must not become too entangled in restrictive relationships (e.g. Staber, 2005), but maintain their freedom to maneuver, bargain and even attack in order to secure their own interests. In other words, firms should be *embedded* in their relationships (Granovetter, 1985) and *independent* at the same time (De Wit and Meyer, 2005).

Power and dependence in networks

Kay (1993) argues that to understand the interaction between firms, it is highly important to gain insight into their relative power positions. Power is the ability to influence the other's behaviour. Power in relationships has been researched from many viewpoints, e.g. with sociological, psychological and managerial theories. However, Belaya and Hanf (2009) argue that regardless the origin, it is agreed upon that the one who has more power has access to more resources, such as higher esteem, praise and positive attention. Since the resources of actors are rarely equal, the outcome of any particular exchange depends upon the relative power of the participants (Davern, 1997; Belaya and Hanf, 2009).

Relationships can be examined in terms of mutual dependence between the parties, and power can be located at the interdependencies among the actors embedded in these relationships (Pfeffer and Salancik, 1978; Belaya and Hanf, 2009). De Wit and Meyer (2005) state that one way of measuring power in a relationship is to make a distinction between the closeness of the relationship (loose vs. tight) and the distribution of power between the two parties involved (balanced vs. unbalanced). This leads to a categorization of four specific types of inter-firm relationships, depicted in Figure 1.

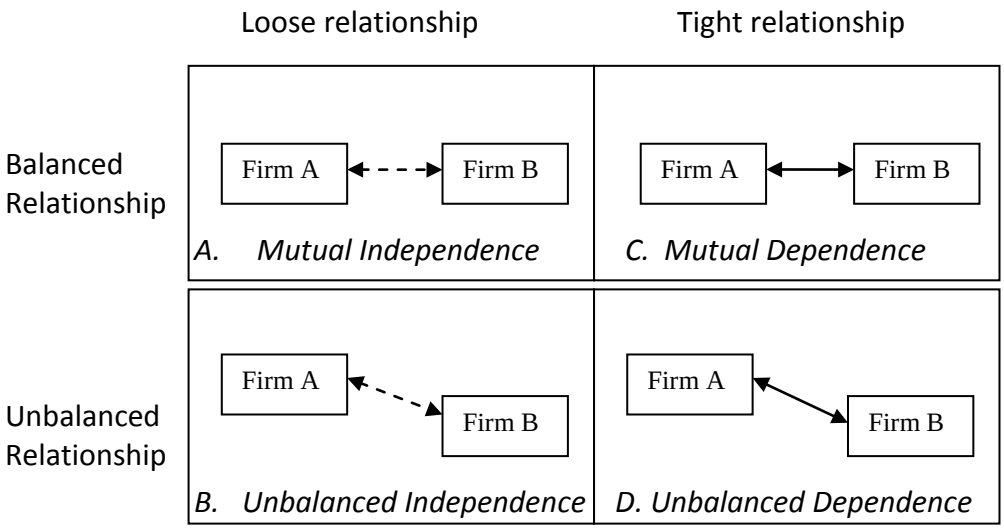

Figure 1: Relative power positions in inter-organizational relationships (De Wit and Meyer, 2005 (adapted from Ruigrok and van Tulder, 1995)).

a) Mutual independence: both organizations have full freedom to act according to their own objectives. Neither organization has significant influence over the other.
b) Unbalanced independence: a loose relationship, where Firm A has more power than Firm B, i.e. Firm A is more independent. Firm A's power gives it more freedom to act, while Firm B can be influenced by the powerful Firm A.
c) Mutual dependence = interdependence: the organizations have a tight relationship, in which they are mutually dependent on each other, having an equal amount of impact on their counterpart.
d) Unbalanced dependence: asymmetrical dependence, where one party will be able to dominate the other. The organization with the lower level of dependence will have more freedom to maneuver and impose its conditions than its counterpart. (De Wit and Meyer, 2005)

Associability in social networks

The networking capabilities of a firm presume building social relationships with the surrounding parties. Several studies suggest that social relationships and personal ties play a crucial role in developing business networks, especially those of small and medium-sized enterprises (see e.g. Hite and Hesterly, 2001; Vanhaverbeke, 2001). It is seen that with the right contacts e.g. the level of uncertainty can be diminished, the risks reduced and critical market information provided. Personal relationships also provide security and trust (Pikka, 2007).

Furthermore, a social network can offer the company business growth and new business opportunities (Pikka, 2007). Social networks help managers to recognize the knowledge possessed by different actors in the network and to understand the relevance of applying that information (Westerlund and Svahn, 2008). Through the actors' social networks, firms have opportunities to update their knowledge in dynamically changing markets and to detect future developments in the industry (Vanhaverbeke, 2001)

According to Nahapiet and Ghoshal (1998), social capital is the sum of actual and potential resources that are embedded in, available through and derived from the network by an individual or social unit. The nature of social capital thus both structures and facilitates the operation of networks and their actors (Anderson and Jack, 2002). Two main approaches emerge in the various definitions of social capital: the *public goods* and *private goods* approaches. In the *public goods* approach, the phenomenon is mainly studied at the macro and meso level, and individual benefits are secondary. Social capital is seen as an attribute of a social unit, and an individual actor either benefits from its presence or suffers from its absence (Leana and Van Buren, 1999). In the *private goods* approach, the social capital focuses on the individual (a person, a group, an organization or an industry) and his or her accrued social assets. The focus in terms of outcomes is always on the individual person or unit and the types of social arrangements and strategies that can work to his, her or its private benefit (e.g. Leana and Van Buren, 1999; Burt, 1997).

In this study, we follow Leana and Van Buren's (1999) view that the above-mentioned approaches need not be in conflict if properly managed. If individuals act in ways that enhance organizational social capital, or as applied in this study, a network's social capital, secondary benefits will accrue to them as well. This requires *associability*, which by Leana and Van Buren (1999) is the willingness and ability of actors in an organization to subordinate individual goals and associated actions to collective goals and actions. It means that individuals will subordinate their personal goals to collective goals which will then be reached for through collective action.

Associability requires more than simply interdependence between the participants; it combines elements of sociability (i.e. the ability to interact socially with each other) with willingness to subordinate individual desires to group objectives (Leana and Van Buren 1999; Wagner, 1995). It can thus be seen that a network's social capital will not appear from "somewhere" but it requires that the actors in the network will use their associability to form collective goals and plan actions to gather them. However, individuals differ in terms of associability (Wagner, 1995) which means that every social tie and every network is always to some degree dependent on the social assets of its participants.

RESEARCH DESIGN

The empirical study was conducted as a case study. Many authors state that case study is not a methodological choice, but a choice of what is to be studied (e.g. Eisenhardt, 1989). In case study research, the central feature is the construction of 'the case' or 'cases'; the research questions are always related to the understanding and solving of the case: what the case is about and what can be learned by studying it (Eriksson and Kovalainen, 2008).

Creswell (2007) sees a case study as an exploration of a bounded system which can be defined in terms of time and place, over time and through detailed, in-depth data collection, involving multiple sources of information which are rich in context. Case studies thus typically combine several data collection methods, such as archives, interviews, questionnaires and observations (Barton Cunningham, 1997; Eisenhardt, 1989).

Case research is particularly welcome in new situations where only little is known about the studied phenomenon, and in situations where current theories seem inadequate (Eisenhardt, 1989; Yin, 2003). According to Halinen and Törnroos (2005) the advantage of case studies over other research strategies is that case research allows the study of a contemporary phenomenon which is difficult to separate from its context, but which is necessary to study within the context to understand the dynamics involved in the setting.

The data for the study was collected during the summer 2010. The research data consists of 52 semi-structured theme interviews: 26 of them with biomass heating entrepreneurs and 26 with the biomass heating system manufacturers. Mainly the data concerning the biomass heating entrepreneurs is utilized in this study, but the main ideas of the interviews with system manufacturers are taken into account. The group of the chosen 26 heating enterprises consists of heating plants in different parts of Finland, with different plant sizes and ownership bases. It can thus be expected that the chosen group represents rather well the group of Finnish heating enterprises.

RESULTS

The results of the study are introduced in this section. On the basis of the theoretical background, two dimensions; independency and associability, were chosen for more profound examination, and on the basis of them, different networking tendencies of biomass heating enterprises were recognized and assessed. In addition, the resource-bases of these enterprises are presented, and the correlation between the resources and networking tendencies of the biomass heating entrepreneurs is examined and discussed.

Analysis of independency and development activeness

Firstly, the question of power relations and dependency on networks was examined by the *"independency"* dimension, which depicts the heating enterprises' tendency to lean on the other actors. Simply put, the more independent the heating enterprise is, the less its partners are involved in its activities. Secondly, the questions concerning the actors' associability were combined to a dimension called *"development activeness"*. This dimension depicts the enterprises' tendency to develop their business and network, i.e. their tendency to share social capital with others. The more active the enterprise is, the more it spends time for planning and developing activities, and the more willing it is to have cooperative goals and activities with its partners, and is also willing to find new partners. Suitable questions in the interviews depicting these dimensions were chosen for more thorough examination. In order to form clear entities and specify the assessment, some questions were combined.

Independency was examined through the following interview questions:

- ownership base: the plant and the heating network
- business activities of the enterprise (if independency was brought out)
- fuel procurement: procurement, delivery, and the enterprise's own forest property and its impact on procurement
- structure of the network and the enterprise's role in the network

- independence from the heating system manufacturer
- distribution of work in maintenance and repair
- (other questions where independency was brought out)

There are clear differences in the ownership base of the plants and heating networks. Some heating enterprises own the plant as well as the network, but in many cases, the network is owned e.g. by the municipality. Differences can also be found between the plants of a certain enterprise – some plants and networks can be completely owned, whereas in others the enterprise only maintains the plant.

Clear differences were also found in the ways the fuel is procured. In some cases, the enterprise seems to take care of the whole procurement chain, whereas in some other cases, the procurement is far outsourced. As regards the maintenance of the plants, some enterprises maintain their plants nearly completely on their own, whereas some have outsourced the maintaining activities.

The business activities and some other questions were also taken into account if aspects related to independency were mentioned by the interviewee. In addition, the network structure and the heating enterprises' roles in their networks, as well as their relationships with the system manufacturers were analyzed regarding their dependency on the partners.

Development activeness was examined through the following interview questions:
- business activities of the enterprise (if developmental activities were brought out)
- willingness to cooperate with heating system manufacturers
- opportunities and challenges of the development of cooperative networks
- planning of new heating plants or other activities
- future views
- (other questions where activeness was brought out)

The enterprises seem to differ in their willingness to cooperate with the system manufacturers and also in the amount of support they are willing to receive from them. In the question of opportunities and challenges of the development of cooperative activities, attention was paid to the interviewees' emphasis on opportunities/challenges and their views on the importance of cooperation. Clear differences were found in the amount of time the entrepreneurs spend on planning their future – some seem to be satisfied with the current situation, whereas others are constantly finding new business and cooperation opportunities, for example in combined heat and power production (CHP). The business activities and some other questions were also taken into account if aspects related to development activeness were mentioned by the interviewee.

In Tables 1 and 2, the heating enterprises are assessed by the above-mentioned dimensions. The sub-questions of both dimensions are assessed with the scale 1-5. The higher the number in the questions related to independency, the more independent the enterprise is. Correspondingly, the higher the number in the questions related to development activeness, the more actively the enterprise develops its network(s) and thus the higher its level of associability. The scores for the dimensions are averages of the scores of the used sub-questions, and in order to clarify the differences between the groups better (see e.g.

Figure 2), the averages have been weighted by 2. As can be seen, the level of independency varies from 5.13 to 8.96. Thus, the differences in this dimension are notable between the groups. Similarly, there are clear differences between the levels of development activeness, as the highest number is 8.49 and the lowest 5.83. The meaning of these differences is further discussed below.

Table 1: Assessment of the independency of the biomass heating enterprises.

BIOENERGY HEATING FIRM	GROUP	Ownership base: plant and heating network	Business activities (related to independency)	Fuel procurement	The structure of the network and the firms' role in it	Independence from the heating system manufacturer	Distribution of work in maintenance and repair	Other questions	AVERAGE	INDEPENDENCY (Weighted by 2)
1	Group 1	5		1	3		1		2.50	5.00
2	Group 1	2		3	3			1	2.25	4.50
6	Group 1	3	4	4	3	4	2		3.33	6.67
13	Group 1	3	2	1	2	2	5		2.50	5.00
14	Group 1	1	2	1	3	5	3		2.50	5.00
15	Group 1	3	3	1	4	2	4		2.83	5.67
21	Group 1	4		3		2	3		3.00	6.00
22	Group 1	1		2	3	3	4		2.60	5.20
24	Group 1	5		1	3	3	4		3.20	6.40
26	Group 1	4		3	3	2	4		3.20	6.40
									2.79	**5.58**
10	Group 2	5		2	2	1	3		2.60	5.20
12	Group 2	3		3	2	1	4		2.60	5.20
19	Group 2			5	1	1	3		2.50	5.00
									2.57	**5.13**
3	Group 3	4	4	2	5	4	5		4.00	8.00
5	Group 3	3	3	2	4	4	2		3.00	6.00
7	Group 3	3		5	4	3	4		3.80	7.60
11	Group 3	5		2	5	3	3		3.60	7.20
18	Group 3	4		2	5	3	4		3.60	7.20
20	Group 3	3	4	1	4	5	3	4	3.43	6.86
23	Group 3	5	4	2	5		4		4.00	8.00
									3.63	**7.27**
4	Group 4	3		4	5	5	4		4.20	8.40
8	Group 4	5		5	5	4	5		4.80	9.60
9	Group 4	3	5	4	4	4	4		4.00	8.00
16	Group 4	4		5	5	4	5		4.60	9.20
25	Group 4	4		5	5	5	5		4.80	9.60
									4.48	**8.96**

Table 2: Assessment of the development activeness of the biomass heating enterprises.

BIOENERGY HEATING FIRM	GROUP	Business activities (related to development activeness)	Willingness to cooperate with heating system manufacturers	Opportunities and challenges of the development of cooperative networks	Planning of new heating plants or other activities	The future views	Other questions	AVERAGE	DEVELOPMENT ACTIVENESS (Weighted by 2)
1	Group 1		3		2			2.50	5.00
2	Group 1		3	2	3	2		2.50	5.00
6	Group 1	4	2	4	3			3.25	6.50
13	Group 1		4	4	3	3		3.50	7.00
14	Group 1		1	2	3	4		2.50	5.00
15	Group 1		4	2	4	3		3.25	6.50
21	Group 1		3	2	2			2.33	4.66
22	Group 1		4	2	4			3.33	6.66
24	Group 1		3	4	3			3.33	6.66
26	Group 1		3		2	3		2.67	5.34
								2.92	**5.83**
10	Group 2		5	2	4			3.67	7.34
12	Group 2		5	3	4			4.00	8.00
19	Group 2		5	5			4	4.67	9.34
								4.11	**8.23**
3	Group 3	5	5	5	5	4		4.80	9.60
5	Group 3		4	5	3	4		4.00	8.00
7	Group 3		4	4	4	5		4.25	8.50
11	Group 3		4	5	3			4.00	8.00
18	Group 3		4	4	4	5		4.25	8.50
20	Group 3	4	5	4	4	4		4.20	8.40
23	Group 3	4	5	3	4	5		4.20	8.40
								4.24	**8.49**
4	Group 4		4	4	3	3		3.50	7.00
8	Group 4		4	2	2	4		3.00	6.00
9	Group 4		4	4	3			3.67	7.34
16	Group 4		4	3	2			3.00	6.00
25	Group 4		5	3	3			3.67	7.36
								3.37	**6.74**

Four groups of enterprises with different networking tendencies can be recognized on the basis of the assessment. For clarity, the enterprises have been already sorted by the below-presented categorization and indicated with group numbers in Tables 1 and 2. The four recognized groups are:

1) *Actors in local networks of equal partners*
   These actors tend to build networks locally, and form tight relationships with other local actors with a certain role in the network. The meaning of locality in the networks is emphasized, and all actors are rather equal in the power relations. In addition, the employment of local people and supporting of small actors are seen as important. This group also includes heating enterprises which are subordinate to a municipality – in these contracts the municipality owns the plant and the heating network, but the enterprise takes care of the business activities and the maintenance of the plant.
2) *Actors with strong relationships with heating system manufacturers*
   These actors tend to build strong relationships with the heating system manufacturers (later HSMs). The plants, with relatively small resource-bases on their own, actively exploit the manufacturers' networks in the maintenance activities of the plants. In addition, these enterprises have common research and development interests with the manufacturers, and they may operate as lead users for them.
3) *Network developers/lead firms*
   These actors are willing to extend the existing networks and build new ones. The networking activities also reach beyond the everyday business and maintenance, as these actors invest in research and development in cooperation with different instances, such as other entrepreneurs, different organizations and educational institutes.
4) *Independent actors*
   These actors tend to be quite cautious in building relationships with external actors. That is mainly because these actors are usually co-operatives or family firms which already have all the needed know-how and expertise on their own. The spheres of responsibilities are clearly divided between the partners. The meaning of personal ties in the formation phase is highly important.

In Figure 2, the enterprises are located in a coordinates where x-axis depicts the independency -dimension and the y-axis the development activeness -dimension. As can be seen, the four above-discussed groups can be easily separated as clusters in the coordinates. Thus, it can be confirmed that each of the researched biomass heating enterprises mainly follows one of the above-discussed networking tendencies.

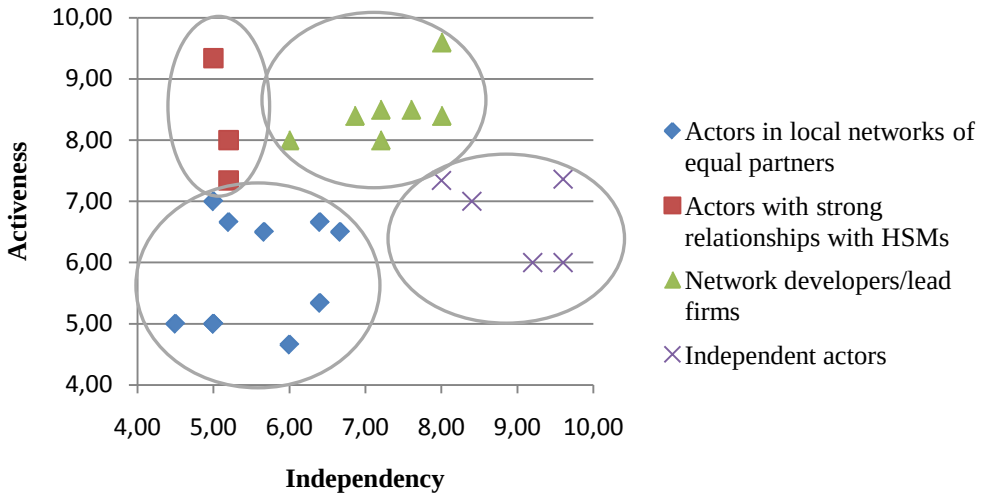

Figure 2: Grouping of biomass heating enterprises according to their networking tendencies.

Next, we look at these four groups more thoroughly on the basis of their relative power positions with their partners by using the framework of De Wit and Meyer, 2005 (see Section 2.1.). In Figure 3, the four groups with different networking tendencies are located in the framework according to the assessments of the groups' characters discussed above.

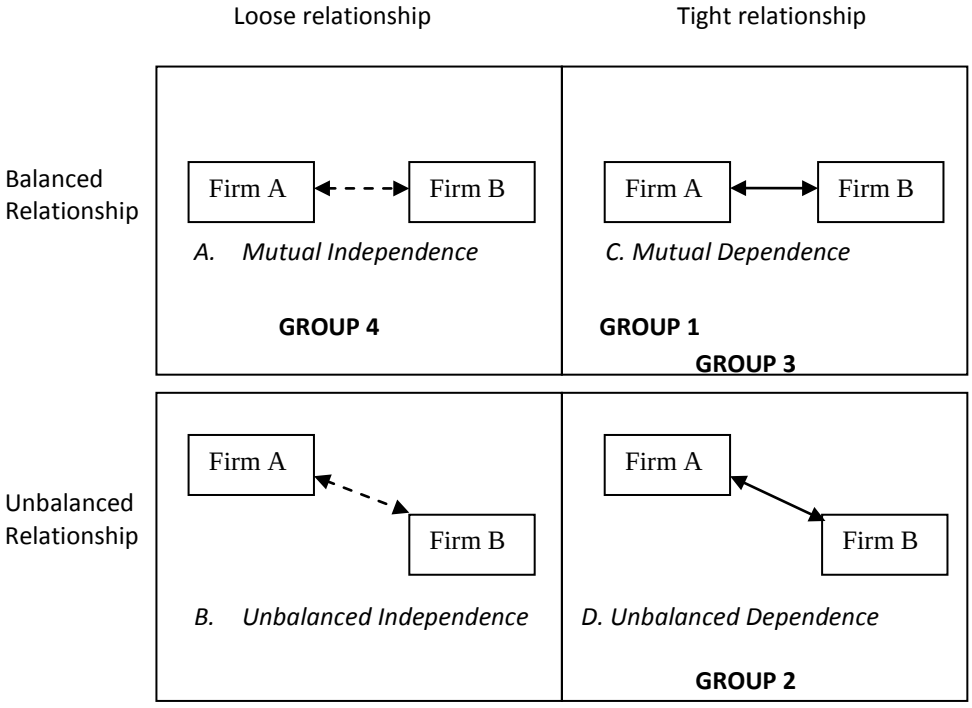

Figure 3: Relative power positions of biomass heating enterprises.

Group 1 (*Actors in local networks of equal partners)* and Group 3 *(Network developers/lead firms*) can be located in the "Mutual Dependence" box. As mentioned above, the actors in local networks tend to form tight and equal relationships with the surrounding actors. Thus, none of the actors in these networks has remarkable power over others. However, each actor in the network is highly important, because each of them has certain, and probably

unique, know-how or resources to share in the network. Group 3 is composed of firms with lively networks which are actively developing business for the common good. Although the networks may include partners rather big in size (such as educational institutes), these actors do not have power over the others, but they are considered as equal research and development partners. The actors are, however, clearly dependent on each other, because none of them is able to develop the business and the network on their own.

Group 2 (*Actors with strong relationships with HSMs)* can be easily located in the "Unbalanced Dependence" box. The networking activities of these actors are mainly targeted at the utilization of the existing relationships of the HSMs. Thus, these firms are not eager to build networks of their own, but they are willing to develop the business in cooperation with the manufacturer and its partners.

The relationships of the firms in Group 4 (*Independent actors)* can be characterized as "Mutual Independence", as these firms do not generally form tight relationships, but their cooperation with the surrounding actors is rather free-form; they occasionally use partners when they need to procure some additional know-how or resources. No partner in these loose networks has power over the others.

In addition, it is appropriate to discuss the level of associability of the groups more thoroughly. The actors in Group 1 (*Actors in local networks of equal partners)* share some of their social capital in their networks, and the operability of the networks is highly based on the unique know-how and assets of different actors. However, as can be noted in the discussion above, these actors are moderate with developing the business or the network from its present scale and scope, or setting cooperative goals for the future. Thus, the total level of associability in these networks is rather low.

At the first glance, the sharing of social capital in Group 2 (*Actors with strong relationships with HSMs)* may appear as open but rather one-way, as the heating enterprises utilize the know-how and social ties of the system manufacturers. However, it has to be remembered that the manufacturers have their own objectives in the cooperation: they can gain valuable information straight from their customers, which the heating plants share openly. In addition, both parties have interests in common development activities. Thus, the level of associability in these networks is rather high.

In Group 3 *(Network developers/lead firms*), associability can be seen as a prerequisite for the networks. The actors in Group 4 *(Independent actors)*, do not tend to share their social capital with others constantly. However, they plan the future and interact with suitable partners (e.g. system manufacturers) if needed. Thus, their associability can be characterized as moderate.

Analysis of the correlation between resources and networking tendencies

Next, we look at the resource- palettes of the biomass heating enterprises. Each enterprise was assessed by six categories of resources, based on the facts collected and comments gathered in the interviews. The examined resource categories are:

- *Human resources:* the number of associates and workforce in relation to the number of plants and their capacity. In addition, the division of active and passive associates is taken into account: how many participants are really involved with the operational activities of the enterprise.
- *Former experience and know-how:* former experience on heating entrepreneurship, entrepreneurship on the whole, or on working in a similar field. Education and theoretical know-how of the entrepreneur/associates.
- *The functionality of the network(s):* the number and activeness of the partners, division of work in the networks. Functionality of cooperation on the whole. The strengths and weaknesses of the network(s).
- *Relationships with HSMs:* amount and regularity of relationships and satisfaction with the cooperation with HSMs.
- *Interest and readiness for CHP:* interest on the whole, readiness of the enterprises' plants for CHP, cooperative activities related to the development of CHP.
- *Physical resources:* number of plants and their capacities.

The assessment of the resources of the biomass heating enterprises is presented in Table 3.

Table 3: Assessment of the resources of the biomass heating enterprises.

BIOENERGY HEATING FIRM	**GROUP**	Human resources	Former experience and know-how of the field	The functionality of the network(s)	Relationships with HSMs	Interest and readiness for CHP	Physical resources	**AVERAGE**	**RESOURCES (Weighted by 2)**
1	Group 1	3	2	3	3		2	2.60	5.20
2	Group 1	3	2	3	3	2	2	2.50	5.00
6	Group 1	5	2	3	2	1	1	2.33	4.67
13	Group 1	1	3	4	4	3	2	2.83	5.67
14	Group 1	4	4	4	1	3	1	2.83	5.67
15	Group 1	3	2	4	2	3	1	2.50	5.00
21	Group 1	2	3	3	3	2	2	2.50	5.00
22	Group 1	3	4	3	2	3	1	2.67	5.33
24	Group 1	3	2	3	3	2	2	2.50	5.00
26	Group 1	3	2	3	2	3	2	2.50	5.00
		3.00	2.60	3.30	2.50	2.44	**1.60**	2.58	**5.15**
10	Group 2	3	4	3	5	2	1	3.00	6.00
12	Group 2	1	4	3	5	3	3	3.17	6.33
19	Group 2	3	3	2	5	3	1	2.83	5.67
		2.33	**3.67**	2.67	**5.00**	2.67	**1.67**	3.00	**6.00**
3	Group 3	3	5	5	5	4	5	4.50	9.00
5	Group 3	3	3	4	2	3	4	3.17	6.33
7	Group 3	1	4	5	5	4	3	3.67	7.33
11	Group 3	3	3	5	3	4	3	3.50	7.00

18	Group 3	3	4	4	4	3	3	3.50	7.00
20	Group 3	1	4	3	3	3	4	3.00	6.00
23	Group 3	3	4	4	4	3	2	3.33	6.67
		2.43	3.86	**4.29**	3.71	**3.43**	3.43	3.52	**7.05**
4	Group 4	4	4	3	3	3	3	3.33	6.67
8	Group 4	4	3	3	3		2	3.00	6.00
9	Group 4	4	5	4	4	3	2	3.67	7.33
16	Group 4	5	5	4	4	3	3	4.00	8.00
25	Group 4	5	5	4	4	4	3	4.17	8.33
		4.40	**4.40**	3.60	3.60	3.25	2.60	3.63	**7.27**

The level of resources does not vary as much as the levels of independency and development activeness between the four groups. However, differences can be found in the averages, and especially, the groups seem to highlight different aspects and resource categories in their resource palettes. These differences are discussed next, and for clarity, they are also highlighted with darker colour in Table 3.

Group 1 (*Actors in local networks of equal partners*) has a rather moderate level of resources in all categories. A notable fact is that their physical resources are rather small, which is explained by their tendency to form rather small local networks with several other smaller actors. The meaning of these local networks is to provide energy for communities and municipalities, and thus the required capacity is rather low. In relation to physical resources, the group has a strong base of human resources, however. This is because each participant in the networks has its special and meaningful role in the business, and the activities are thus highly chained. In all, however, the level of resources is lowest in this group.

The levels of the human and physical resources of Group 2 (*Actors with strong relationships with HSMs)* are low. This is because these enterprises are rather small in size and they lean strongly on the bigger HSMs and their business relationships. However, the level of experience and know-how in this group is high, which is explained by the fact that these actors gain and develop their know-how together with the HSMs, for example by common R&D activities. Naturally, the relationships with the HSMs are considered as extremely valuable in the group.

Group 3 *(Network developers/lead firms)* has quite a strong resource palette. However, their own human resources are not very large, because their activities are well-networked and thus they utilize a lot of external human resources in their business. The functionality of the networks is naturally experienced as high, although the actors are well-committed to further development of their relationships and building new networks. The interest and readiness for CHP is rather high, and especially the strong physical resources support the development of new technologies – for example, many plants driven by these enterprises are rather big and have thus more potential to CHP production than the plants of Groups 1 and 2.

Enterprises in Group 4 *(Independent actors)* have a high level of human resources – a majority of the business is driven by own resources, and thus these enterprises also need a large amount of active personnel. In addition, their experience and know-how is notably high – their utilization of external forces is much lower than in the other groups and thus they need a strong basis for their business. This experience and know-how is gathered e.g. as a heritage in family firms, or it can be a coalition of differently experienced people from different fields who have gathered together and formed a company or cooperative where the spheres of responsibilities are clearly divided. Because the enterprises in this group do not tend to form long-lasting relationships with external parties, the functionality of the networks and the relationships with HSMs could not be assessed as thoroughly as in the other groups. However, according to the answers, the actors seem to be quite satisfied with the contracts they have had with external parties. In all, the level of resources is highest in this group.

Table 4 sums up the results. As can be seen, the resource analysis supports rather well the above-discussed characteristics of the four biomass heating enterprise groups with different networking tendencies. It can thus be stated that the resource-base of an actor correlates rather strongly with its networking tendency. In the case of Group 1, the actors lean on each other and form a tight network via which they can operate locally. The resource-bases of the actors are rather low, which makes the actors equal – none of the participants in the network has significant power over the others. Enterprises in Group 2 are rather small in size and they are thus dependent on the stronger partners, especially HSMs. However, they are also desirable partners for HSMs because of their strong experience and know-how in the field, and their willingness for cooperative R&D. Group 3 consists of enterprises with a rather strong resource base, which they also eagerly share with their partners. As the partners in their networks are mutually dependent on each other, they both give and gain a lot of their relationships. Enterprises in Group 4 stand strongly on their own feet, which is also shown in their resource- palettes – they possess a sufficient amount and combination of inner resources and do not thus have a need to form tight relationships. Although both the Group 3 and Group 4 have rather strong resource bases, their philosophy to do business is rather different, and this is also reflected in the aspects they highlight in their resource-palettes.

Table 4: Summary of the results.

Group	Type	Power relations	Level of associability	Level of resources	Specialities in resource palette
1	*Actors in local networks of equal partners*	Mutual dependence	Low	Low	Small physical resources
2	*Actors with strong relationships with HSMs*	Unbalanced dependence	Rather high	Moderate	Small human and physical resources Strong experience and know-how Strong relationships with HSMs
3	*Network developers/lead firms*	Mutual dependence	High	Rather high	Rather small human resources High functionality of networks High interest and readiness for CHP
4	*Independent actors*	Mutual independence	Moderate	Rather high	Strong human resources Strong experience and know-how

DISCUSSION AND CONCLUSIONS

Balancing between independency and embeddedness is not an easy task for firms, and the results of the study indicate that firms can solve this problem in many different ways. Every firm has its own objectives related to its independency and associability, which means that every firm tends to maintain a certain level of independency in its relationships, and that it also has a certain willingness and capability to share its social capital with its partners. These objectives lead to formation of different networks. In the researched group of Finnish biomass heating enterprises, four groups with different networking tendencies based on these objectives could be found. These objectives need to be taken into account when planning networked businesses – even though some firms might seem as perfect partners because of their business fields or technical prospects, they may have totally different aims related to their networking tendencies.

The results indicate that there is certain correlation between the actors' resources and their tendencies to form networks. For example, a rather small resource-base of a firm seems to lead easily to the formation of tight relationships with other small actors - the actors lean on each other, but none of the participants in the network has significant power over the others. In addition, because of the limited amount of resources, the networks do not have ambitions for wider development, and thus the level of associability in these networks is low. On the other hand, with a higher level of associability, a small firm can also network

with a more powerful firm (HSM) and concentrate on strengthening its experience and know-how through cooperative activities.

Actors with stronger resource- palettes seem to have two, rather diverging networking strategies, depending on their objectives of the independency-level, and their associability. In the network developers/lead firms' case, the activities are well-networked and the firms utilize a lot of external human resources in their business and do not thus have a remarkable number of human resources of their own. As the partners in the networks are mutually dependent on each other, they both give and gain a lot in their relationships, and thus the level of associability is high. In the independent actors' case, the situation is rather the opposite – these firms possess a sufficient amount and a suitable combination of inner resources, and because of their objective for a high level of independency, they do not need to build long-lasting relationships with other actors.

It must be remembered that the study has concentrated only on certain dimensions related to networking, and there might be many other factors impacting the actors' decisions. However, these dimensions were formed on the basis of a widely-discussed theoretical background and a relatively large set of interview questions. Thus, it can be expected that these issues are seen important and highlighted in the actors' aims of building business relations and networks.

Although the focus of the study was on biomass heating entrepreneurs, the results can be expected to reflect the situation in many fast-evolving business fields, and that way to offer fresh and wider knowledge on the issues under scope. For the actors themselves, the study offers a clear view on their tendencies to form relations and networks and thus helps them to develop their business better according to their objectives.

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H1 – Innovations in higher education

H1.1 **Evaluation framework for university-enterprise co-operation**
Atte Niemelä

H1.2 **Findings from European benchmarking exercises on e-learning: Value impact and going beyond**
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H1.5 **The study of EL feature implementation in the KM perspective**
Somchai Numprasertchai

EVALUATION FRAMEWORK FOR UNIVERSITY-ENTERPRISE CO-OPERATION

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ABSTRACT

As the status of academic research institutions is changing, the way they operate must also be placed under scrutiny: the operating customs and organization cultures must be transformed so that they fit and support the role that the universities and their units have been assigned. To be able to change these customs, cultures and their outcomes, one needs to be able to evaluate them. The goal of this study is to create an evaluation framework to address this need.

In this study a model for the evaluation of university-industry (U-I) co-operation is created. To support this, success factors of U-I co-operation and benefits of evaluation are also studied. The presented evaluation framework is based on the European quality award criteria and modified to answer the characteristics of U-I co-operation recognized in the study and prior research. The framework is tested via a brief pilot study and through a comparison with the identified U-I co-operation success factors. The framework was found to be meaningful and understandable, and linkages to the success factors were identified. The results suggest that through evaluation the U-I cultural gap and the arising challenges can be met, and ways to improve university-industry co-operation can be systematically found.

Keywords: University-industry co-operation, university-industry, evaluation

INTRODUCTION

The interest in co-operation between industry and universities (U-I co-operation) has been increasing both in Finland and globally. The economic structure of universities has changed and it has increased the gap between public funding and research expense, making this co-operation even more necessary (Bonaccorsi and Piccaluga, 1994). Universities have started to expedite and prefer a variety of diverse collaborative by more formal structures which have brought about explicit leadership for knowledge and technology transfer as well as two-way knowledge flows (Santoro and Chakrabarti, 2001). For firms, universities are

important and natural partners and a source of new knowledge, technology and procedures (Confederation of Finnish Industries EK, 2009; Santoro and Chakrabarti, 2002).

Suggestions on how those relationships should be established and maintained have been proposed, but U-I co-operations have traditionally been informal, casual and based upon personal contacts (Mead et al., 1999). It has been suggested that the most common and natural reason for casual and non-systematic U-I co-operation is the lack of workable structures (Confederation of Finnish Industries EK, 2009). To move from a mostly ad hoc-based state into more systematic ways of collaboration one needs to be able to evaluate the current operations and results of one's methods of U-I co-operation. The goal of this study is to provide a framework for evaluating university-industry co-operation.

To support the creation of this evaluation framework, the following research questions are answered in the study:

1) What are the success factors of co-operation between academic institutions and industrial organizations?
2) How can university-industry co-operation benefit from evaluation?

It was decided that the evaluation framework would be built on an existing and widely used evaluation model. From the options available, the European quality award model (EFQM model) was chosen because of its holistic approach and the researchers' familiarity with the model. The research questions are answered through a literature review in chapters 2-4 and based on the answers and an evaluation framework is created in chapter 5.

UNIVERSITY-INDUSTRY CO-OPERATION

Co-operation between universities and enterprises takes place continuously. The aims of these different co-operative measures are always mutual benefits: a successful co-operative endeavour should deliver value for both participants. Unfortunately this is not always the case. Sometimes the collaborative effort fails to reach a sufficient level for both participants. Usually this leads to the termination or drastic restructuring of the collaboration. The imperfections of opportunity recognition are also an issue. Precious opportunities for value creation through co-operation are from time to time missed due to different reasons, but the reasons usually they have a common denominator as a root cause: the failure to recognize the possibility for and value in co-operation. A classic example of value in co-operation is the iterated Prisoner's dilemma, in which short-term lack of co-operation leads to a higher payoff but destroys the possibility for co-operation in the future. (Axelrod 1987)

University level research in itself clearly provides valuable results for industry and the society as a whole. Since the establishment of the university system in Finland (and elsewhere) the scientific communities enclosed within the university have provided the surrounding society with new findings, which in turn have led to new technologies developed either by the university or by an enterprise that utilizes the results. The latter is usually called university–industry technology transfer, which is a form of university-industry co-operation. (Siegel et al. 2003) Although a well-known form of co-operation, it is only a single form of multiple variations and options present in the university-industry-interface.

Although the options for the nature of the co-operative relationship are multiple, they still share many common factors.

Different forms of co-operation

The co-operation between a university and a company can have different forms. The modes of co-operation can differ vastly in their planned duration, which usually is the defining factor in addition to available resources (Aapaoja 2011). The relationship can be formed on the idea of doing research, developing new technologies or strictly solving a clearly defined problem. One could say that the stricter the aims and goals of co-operation, the smaller the scope and shorter the duration of the co-operation (not to say that co-operation is always discrete – it can be also continuous).

The reasons for choosing a mode of co-operation are multiple, but at the bottom both the need of the company and the offering of the university should match for a satisfactory result. Prior studies have shown a positive correlation between sales per employee and university co-operation in R&D for companies. (Belderbot et al. 2004) Despite this general positive effect of U-I co-operation, each case has to be considered individually to achieve success. For this purpose the offering, the services that a university can provide for a company have to be defined. The idea behind this definition or productization, if you will, is to make the offering transparent which in turn allows potential participants to deduce the potential value added of service usage or product acquisition. (Simula et al. 2008) If this weren´t the case, how could we even measure the joint performance? A university has to be able to define its offered services and the company has to know what it needs or the joint effort has little chance of succeeding satisfactorily.

The different actors on the industry side can be classified as collegial, aggressive or targeted players. Collegial players are strategically oriented, targeted players have an interest in operational problem solving and aggressive players, who have features from both collegial and targeted players could be said to be after competence building. The focus of co-operation is related to the nature of the player. (Santoro and Chakrabarti 2001)

We can specify five different forms of U-I co-operation. Santoro and Chakrabarti (2001) present U-I co-operation as having four possible forms: research support, knowledge transfer, technology transfer and collaborative research. We can also add educational interaction as a fifth possible mode for co-operation. (Aapaoja 2011) The objectives and goals for each relationship between a university and a company are different (and naturally, so are the contents of their co-operation agreements) (Valentin 2002). The co-operative endeavors can still be studied using the five different forms mentioned.

Research support is a co-operation form with little interactivity. It consists of donations from the industry to the university. Expectations for results and outcomes can be almost nonexistent. In the past, a research grant or donation could be given without clear specifications, although nowadays the research projects are usually specific. An entity supporting research cannot be sure whether the research will provide new technologies or competencies. Ergo, this is a form that suits the collegial players better than the others. (Aapaoja 2011)

Knowledge transfer is a long term mode of co-operation. It consists of highly interactive modes of knowledge transferring, e.g. participation on curriculum planning, personnel exchanges, consortia and information and knowledge transfers. Clearly the mode is one that demands time, resources for interaction and established relationship between the actors. It should be noted, that knowledge transfer can occur through informal relationships as well.
Technology transfer is a form in which the collaborators usually pair for doing new science with specific problems in mind. The co-operation can consist of short-term projects, solving of specific problems, joint ventures and consultation. It has features that can be found in collaborative research as well, but the modes differ in scope and duration. In collaborative research the company usually has a goal in mind and needs the aid of the university player for reaching said goal. Methods of collaborative research are thesis works made for the company, university support for R&D projects and operational analysis and finding new technological opportunities through research projects. (Aapaoja 2011)

The final mode of co-operation is educational interaction. In this mode the industry player offers its actual (small) problems for study purposes (e.g. cases), visiting lecturers, participates in seminars and organizes further education for its personnel. (Aapaoja 2011)

Success factors

We must bear in mind, that although co-operation between the universities and firms has been prevalent for a long time, actual interaction between the parties has not (and is) always not been a norm. According to theory the role of a firm in technology transfers is merely to commercialize the new technology for a financial gain through licensing (Siegel et al. 2002). This obviously presents some issues: if the industrial players are not influencing the research decisions, the possibility of developing futile technology is present. Also, marketing new technology to the industry incurs costs for the university – finding a partner willing to license the technology may be a hard task. Finally, the costs of negotiation can also be hefty: as a perfect agreement is nigh impossible to be written, there is always a risk of abusing the contract terms. The solution that Siegel et al. propose is the bridging of the cultural gap between academia and industry. Clearly, the best way of closing the gap is interaction between the actors. When building the co-operation through a continuous relationship rather than discrete events the risk of futile research and misuse falls. The partners must consider the needs of each other and share the goals and objectives. The development of a successful co-operation relationship is presented below in Figure 1 (Aapaoja 2011).

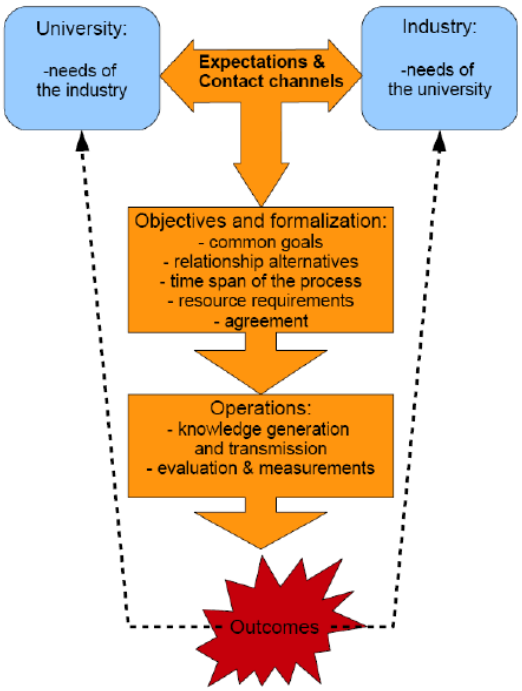

Figure 1: Development process of U-I co-operation (Aapaoja 2011)

It is quite intuitive, that the proper identification of the needs for both parties is important for success. If the needs are not identified to a sufficient degree, the goals set for the collaboration will most certainly be either insufficient in terms of e.g. financial attributes or plainly wrong. When the goals are set incorrectly, the results of the collaboration will be unsatisfactory for the party whose needs have not been identified correctly. This error in the identification process is a potential source for problems or conflicts in the co-operation. Therefore a great deal of attention must be paid to the identification of needs – only when the needs of the collaborators are clear can the goals of the co-operation be set so that they satisfy both participants' intentions.

The Confederation of Finnish Industries EK (2009) has identified some relevant factors that are helping to achieve the objectives of co-operation – figure 1 supports the following factors:

- Identifying needs and offerings of industry and universities,
- Members understand each other's roles, objectives and expectations
- Active information sharing and popularization by universities
- Multiple ways to co-operate
- Universities have a clear contact channel and rules for different collaborations
- Co-operation shares common perspectives and goals and it is aimed at long- term collaboration
- Firms provide sufficient resources for co-operation and to the commercialization of the results.

Siegel et al. (2003) mention the cultural gap between the industrial and academic organizations as a phenomenon that must be accounted for in U-I co-operation. Essentially the gap must be bridged, so to speak, through different actions by the participants so that

the language and essential nature of the organizations are clear to the collaborators. When the gap is successfully closed, the co-operation will most likely prove to be more effective and efficient, as the collaborating entities know each other thoroughly.

EVALUATION

To evaluate something is no trivial task. When one evaluates the actions, we must decide the evaluation criteria, the target of evaluation and the way the evaluation results are utilized for the evaluation to have a purpose. Obviously evaluations can be carried out for different reasons, but for our purpose it is reasonable to assume that the purpose of the evaluation is to better and further develop the actions of the organization. As Stufflebeam (1985) has stated: “The fundamental purpose of evaluation is not to prove, but to improve”.

When we evaluate a scientific organisation or its interaction with external stakeholders it is important to bear in mind the intrinsic nature of the organisation: its main task is to create and distribute new knowledge and information. The cycle of new knowledge creation is evidently a major element in the university context (Nonaka 1994). It is in the end continuously in use in a scientific research organisation. At a first glance it would seem that evaluating the outputs of the organisation would be a trivial task, but the tasks in the cycle are not so easy as they seem. The nature of scientific knowledge is often complex and highly specialised. Therefore codifying it to a communicable form can be difficult and more importantly, measuring the value and effect of said output - new knowledge or technology – is difficult. Nonaka et al. (2000) base their view of an organisation as a knowledge creator to the assumption that organisations interact with other organisations and their own environment. As knowledge is not static, but changed through interactions, we can assume that all occurrences of interaction have an effect on knowledge. The only way to evaluate an organisation accurately is to externalise knowledge. It would take a person not unlike Laplace’s demon to monitor the causalities and outputs exactly as they are, but if we codify the outputs of knowledge creating processes to a quantitative form or find indicators that represent the efficiency and effectiveness of said processes, we can also evaluate how the processes perform. In a nutshell, this is exactly what evaluation is about: find indicators that represent the evaluated phenomenon, measure, compare to targets and utilise the results.

Evaluation can be either external or internal. In the case of external evaluation common types are audits, assessments and reviews by outsiders. This is in contrast to internal evaluation, where the organization assesses its own actions. The use of internal evaluation can easily be justified – by judging the organizations actions critically can development take place. Internal evaluation can be an audit, a program evaluation or a self-assessment. (Kauppila et al. 2011)

The process of evaluation can be divided to 7 steps. These steps are 1) the assessment for the need of evaluation, 2) the formulation of the evaluation task, 3) the choosing of the evaluation concepts and building the evaluation criteria, 4) planning and launching the evaluation, 5) collecting and analyzing evaluation data, 6) reporting the results, conclusions and development recommendations and finally 7) the utilization of the evaluation information. (Virtanen 2007).

The evaluation process can be carried out regardless of the target of evaluation. When combined with e.g. the context, input, process and product evaluation model by Stufflebeam (2002), one gets a solid frame of reference on how to proceed with the evaluation task.

Stufflebeam's CIPP-model (Context, Input, Processes and Products) is an evaluation model that emphasizes improvement. It is a comprehensive tool for evaluating an entity's actions in their entirety. We begin by assessing the context: the needs, problems and opportunities. The purpose is to provide decision-makers with help in target and goal definition. The input evaluations focus on comparing different courses of action and their usefulness for achieving the objectives. The process evaluation phase assesses the effectiveness and efficiency of the activities carried out in the organization during an endeavour and finally the product evaluations assess the outcomes of the effort. (Stufflebeam 2004)

As per CIPP-model, the context, input, processes and products must be evaluated. Rossi's approach (1999) is very similar to Stufflebeam's model. According to Rossi et al. successful evaluation is based on accurate performance measurements that are compared to the chosen criteria. Obviously for such criteria to exist, the domain in which an evaluation is carried out must be assessed beforehand. These domains include the need for a program, the design of a program, the program implementation and service delivery, program impact or outcomes and finally, program efficiency. (Rossi et al. 1999: 35)

To evaluate the operations and actions carried out by the target of evaluation the scope and level of evaluation must be accurate. If trying to find out how to boost individual performance, for example, measurement at unit level will hardly give the evaluating party useful information. Virtanen (2007) points out, that evaluations can and are carried out at different organisatory levels. The scope of evaluation should be related to the level of evaluation: if we are to evaluate the performance of a unit or perhaps an individual, it is mandatory to draw the lines for the evaluation so, that the evaluated phenomena are ones that the target of evaluation has a real chance to effect with their actions.

EFQM EVALUATION MODEL

Evaluation is and always will be a task that demands a balance regarding the evaluated phenomena. Much research and thought has been given to the evaluation decisions that give an organization the possibility of effective decisions. Obviously for the management decisions to be correct, the information gathered through evaluation must give an accurate depiction of the actions measured. In another words, data from the processes and results must be processed to information that can be used as an aid for management tasks for controlled and planned management to be possible.

The EFQM model is the result of the collaborative effort by 14 major European companies. It is a model that has been developed for the purpose of intra-organizational self-evaluation. It is the view of many that to properly function, the TQM practices should be integrated, and not be a separate function ran alongside the main processes. The main philosophy of the EFQM approach is that quality management should be an all-encompassing activity in an organization for it to truly succeed. Quality should be managed, maintained and

implemented through actions throughout the whole organization's processes, the outcomes of which should always meet stakeholder expectations. (Davies 2008, EFQM 2003, Nabitz and Klazinga 1999)

The evaluation in the EFQM approach is targeted to the organization's processes and the outcomes of those processes. This twofold model ensures that the measurement is comprehensive. Data shows, that the use of total quality management approach is an effective management decision: when tracked for a five-year period quality award winners achieved significantly better results when compared to a control group. As the EFQM Model is very connected with the TQM principles and best practices, the model can be said to be a highly usable tool in the search of better results. (EFQM 2003)

It is good to remember, that the EFQM Model itself is no answer or a trick for achieving improvement. The results of assessment must be utilised for them to have an effect. The Plan-Do-Check-Act –cycle of management is a good rule of thumb. Begin by formulating a strategy, execute said strategy, assess the outcomes and act based on the results. (CAF 2006, Michalska 2008)

As mentioned before, the EFQM model is twofold: both the enablers (processes) and the results (outcomes of executing said processes) are assessed. The basis of the Excellence Model is the fundamental concepts of excellence, which are listed below (EFQM 2003):

1. Results Orientation
2. Customer Focus
3. Leadership and Constancy of Purpose
4. Management by Processes and Facts
5. People development and involvement
6. Continuous learning, Improvement and Innovation
7. Partnership Development
8. Corporate Social Responsibility

The fundamental concepts are closely linked to the evaluation criteria of the model. The evaluation criteria itself has nine categories, which show the links to the fundamental concepts at the first glance. The evaluation categories are presented Figure 2.

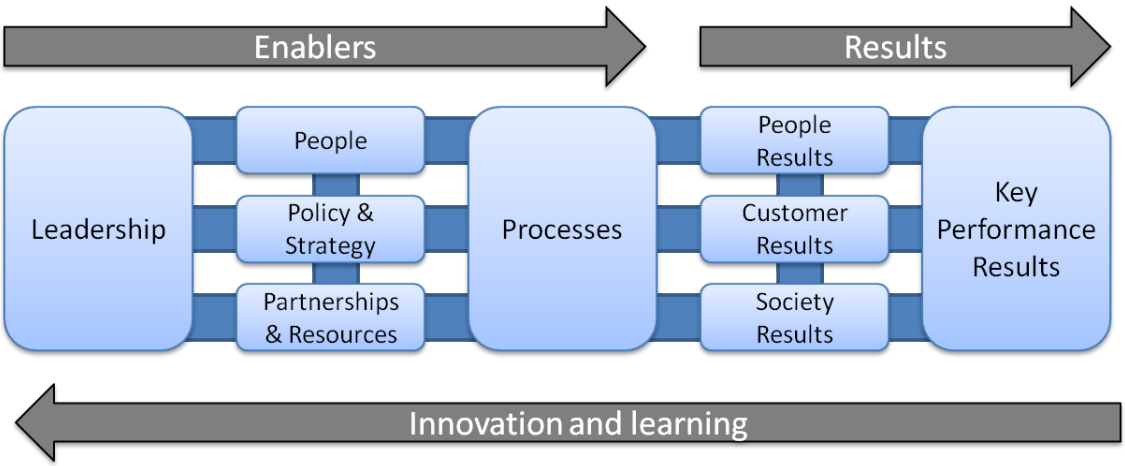

Figure 2: The categories of the EFQM evaluation criteria.

In the first evaluation criteria the assessment targets leadership: are the leaders doing their part in implementing and enabling the achievement of the strategy. According to the criteria the leaders should actively partake in interaction with the stakeholders that the organisation has, manage change and support a culture of Excellence within the organisation. Personal involvement in management system development, implementation and improvement is also seen as the role of managers and leaders need to take. (EFQM 2003)

The links within the model are evident. When we proceed to the next category, Policy and Strategy, the evaluation criteria are based on the consideration of stakeholder needs and expectations in addition to giving weight to the use of information and performance measurements in the formation of policy and strategy. in addition to the formulation of strategy the development, updating and thorough communication of the strategy are emphasised. (EFQM 2003)

The third category is associated with human resource management. Its purpose is to assess how systematic and planned the management of human resources is, how the knowledge and competence of human resources is managed, whether the workforce is empowered and involved and how the organization and the people it consists of interact with each other. In a sense it could be seen to be connected with the fourth category, Partnerships and resources, in which the usage and management of external partnerships, finances, assets, technology and information and knowledge. (EFQM 2003)

The fifth enabler category, Processes, focuses on the processes carried out in the organisation: how they are managed, developed and improved. The goal of an organisation is to create, develop and manage processes so, that the value they create for stakeholders increases continuously. An organisation that strives for excellence should have processes that are designed and planned, yet further improved as new possibilities for value creation arise. EFQM Excellence Model emphasises the stakeholder needs, and this category is no exception. According to the criteria the stakeholder needs and expectations should be the driving force behind Product and Service development efforts. Furthermore the customer relationships need to be systemically managed and developed to achieve Excellence. (EFQM 2003)

The second part of the twofold EFQM Model measures the outcomes of the so-called black box: the results of the processes that the organisation has carried out. When the results are measured, four categories are differentiated: People, Customer, Society and Key Performance. People and Society Results are measured by two factors, perception measures and performance indicators. The performance measures are e.g. career development, empowerment, employment conditions and working environment (for People) and image, performance as a responsible citizen, community involvement and reduction of harm from operations in (for Society) and finally for Customer results Image, Products and services etc. It is noteworthy, that the Perception measures are derived from how the workforce and society perceive the organization (ergo Perception Measures). The Performance Indicators on the other hand are the organisations own internal measures on how it conducts itself regarding personnel and the surrounding society. (EFQM 2003)

The Key Performance Results are possibly the most critical in terms of how organisation's performance is usually measured. They consist of Key Performance Outcomes and Indicators, which in turn hold different measures depending on how the organisation has decided to measure its results in internal reporting. The Key Performance Outcomes are e.g. financial outcomes such as sales, share price, profitability and investment and asset performance and non-financial outcomes such as market share, time-to-market, success rates etc. The Indicators are the set of measures used to evaluate the performance outcomes. These are financial indicators such as cash flow, depreciation, project costs and credit ratings and non-financial indicators such as process performance and cycle time, external resources available, technology available and information and knowledge available. (EFQM 2003)

CONSTRUCTION OF U-I CO-OP EVALUATION FRAMEWORK

During the study, an EFQM based framework for assessing university-industry co-operation was constructed. One of the aims of the framework was that it could be used to evaluate U-I co-op from both the university and the industry viewpoint. Besides the theoretical overview above, prior research conducted by Aapaoja (2011) as a part of his Master's thesis were also used in editing the model from the original EFQM criteria. A brief pilot of the model was also conducted. The model was reviewed against the recognized success factors to further validate its fitness for use.

Results from prior research

Co-operation presents valuable opportunities for both the university and the industry. The university/department can gain funding, create new networks and also gain new insights and knowledge through co-operation. The industrial participants can gain knowledge, new technologies, solutions to problems and e.g. new recruits. All in all, the co-operation can be mutually beneficial. Still, the co-operation is relying on personal contacts and interests and executed on an ad hoc –basis. The players (especially industrial players) rarely have a documented process or strategy for co-operation, which means that the co-operative efforts are discontinuous in nature. When the collaboration is formed on the personal contacts, relationships between the organisations become quite complex and tangled. When there are many contact interfaces and personal relationships, it can be hard to co-ordinate and most importantly measure the whole co-operative effort. Basically this means, that we must set the scope and level of the evaluation accordingly: we cannot expect to correctly measure the entire collaboration between e.g. a global telecom company and all its university co-operation. We must instead focus on unit and project level evaluation.

The activity of the faculty (professors, researchers etc.) and the employees in the private sector and the existing contacts between the department and the industry seems to be the key factor in the volume, nature and diversity of co-operation at the moment. The task is far from trivial, yet formal, documented processes are hardly implemented to aid in getting the job done. Due to the low level of organisation in the co-operative efforts leads us to a point where the evaluation, assessment and development of said efforts can be merely educated guesses and rather unorganised as well. Clearly a need for an evaluation framework exists. According to prior results in total quality management research and experiences in practice

in industry, the diversity in which the EFQM Excellence Model is usable evaluation framework is massive. The strength of the EFQM Approach lies in its relative simplicity and standardisation – the end result (evaluation framework for U-I co-operation assessment) should with minor changes be applicable to other U-I co-operation conducting organisations as well regardless of their role (university or industrial player) or position in the network.

Review framework for evaluation of co-operation

The review framework has been constructed following closely the EFQM Excellence Model. The RADAR logic is applied as it is presented in the EFQM Excellence model, and the criteria have been modified slightly so that they would represent and allow the evaluation of all phenomena occurring in the U-I –interface accurately. The weights appointed to different criteria are those of the standard EFQM Model and are listed in parentheses next to the criterion name.

1. LEADERSHIP (10 %)
a) Leaders develop, execute and implement the strategy of the co-operation and lead the effort in a way that gives an example Excellence.
b) Leaders drive the development and improvement of use of management systems in co-operation.
c) Leaders recognise and interact with the industrial/university stakeholders, research partners and surrounding society
d) Leaders communicate, support and inspire a culture of Excellence in co-operative endeavours.
e) Leaders identify the need and causes for change and execute change management successfully.

2. STRATEGY (8 %)
a) Information about the needs and expectations of the stakeholders is used as the basis for co-operation strategy creation
b) Performance measurement, research and learning are utilised in the formulation of co-operation strategy
c) The changing needs and context of operation are noted in the strategy process and used in co-operation strategy development
d) The co-operation strategy is communicated efficiently and clearly througout the organisation.

3. PEOPLE (9 %)
a) The people resources utilised are continuously developed.
b) The relevant skills, competences and knowledge of the people are identified. People are encouraged and enabled to improve said attributes.
c) People are empowered and involved.
d) The people have a way to shape the nature of collaboration. Dialogue between people and the organisation is genuine.
e) People are treated as individuals and rewarded, recognised and cared for.

4. PARTNERSHIPS AND RESOURCES (9 %)

a) The collaborative partnerships are managed
b) The financials of co-operative efforts are planned and managed
c) The equipment, materials and other assets used in the co-operation are planned and managed.
d) Technology is managed.
e) Information and knowledge available for and created through co-operation are managed.

5. PROCESSES (14 %)
a) The co-operation related processes are designed and managed
b) The processes of co-operation are improved according to the needs for better value delivery
c) The services offered are developed and designed according to stakeholder needs and expectations
d) The organisation's deliverables from co-operation are produced according to plans, delivered in a timely manner and support is provided as needed.
e) The co-operative relationships are managed and enhanced.

6. CUSTOMER RESULTS (20 %)
a) To what extent do we measure customer and/or co-operation partner satisfaction?
b) Do we have a sufficient set of performance indicators in use?

7. PEOPLE RESULTS (9 %)
a) Do we measure the satisfaction of employees in co-operation projects sufficiently?
b) How extensive is the selection of Performance indicators?

8. SOCIETY RESULTS (6 %)
a) Do we carry out surveys on how the surrounding society views our collaborative efforts?
b) How extensive is the selection of Performance indicators?

9. KEY PERFORMANCE RESULTS (15 %)
a) Do we assess co-operative performance extensively through a set of financial and non-financial measures?
b) Do we have an extensive set of key performance indicators for internal evaluation of co-operation?

During the research, the model was briefly tested and discussed in a meeting with representatives from DIEM and an industrial partner. Both parties agreed that the model seems relevant for evaluating U-I co-operation. It was pointed out that finding metrics is sometimes problematic, especially from an industry viewpoint.

To support the improvement of U-I collaboration, the model should be compatible with the success factors presented in Chapter 2.2. Table 1 illustrates how the areas of the evaluation model are linked to the success factors:

Table 1: How the evaluation framework is linked to the success factors.

Section of the framework	Success factors of U-I co-operation
1. Leadership	Through defined ways to lead U-I co-operation the problem of person-centred ad hoc co-operation can be lessened
2. Strategy	Clearly defined goals help to identify partnership opportunities and communicate when searching for common goals
3. People	The responsibilities, roles and competence required for successful U-I co-operation are defined
4. Partnerships and resources	The responsibilities and resources needed for U-I partnership management and the management of created knowledge are defined
5. Processes	The processes needed for successful U-I co-operation are made visible by, for example, recognizing and communicating various services offered and productization
6-9. Results	The goals defined in strategy are monitored through selected metrics and used in decision-making.

DISCUSSION

The evaluation of co-operation is, all in all, a task that at a first glance seems easier than it truly is. Prior research and the observations during this study suggest that the use of management and quality frameworks in the context of university-industry co-operation can have positive effects on the outcomes of co-operation in almost every conceivable aspect. The use of frameworks and systematic evaluation, be it different quality models and assessment criteria or management models can be utilised when working toward lowering the starting threshold of co-operation and more effective co-operation.

The use of frameworks and quality models can benefit all organisations indirectly as well: when the processes are documented and structured and the organisations use prior experiences to learn how to co-operate with one another, the learning curve can be steepened. When organisations gain experience in co-operation in the university-industry interface, the first phase of the relationship lifecycle can possibly be completed more swiftly when establishing a new collaborative relationship in the future.

The most challenging task regarding evaluation is to find the correct phenomena to measure and to decide the indicators for success or failure in those phenomena. As profit and other monetary gains occur in a relationship continuum at irregular intervals (if they occur at all), the indicators used to measure the success have to be such that the set of indicators does not favour indicators derived from financial figures too heavily. When measuring progress in a context such as that of university-industry co-operation, other indicators must be emphasised. This clearly presents an obstacle for the justification of U-I co-operation: as

companies are legally bound to strive to make a profit for the stockholders, a way to prove the benefits of U-I co-operation must be found. In practice this means, that the outputs of co-operation have to be possible to trace and measure. If the outputs cannot be easily transformed to a quantitative for, i.e. raw numbers, some other way must be thought of to determine the value of the outputs.

Although the use of frameworks helps to set up a structured, documented co-operation process, the ad hoc –nature of collaboration in the U-I interface will hardly vanish even if the use of quality frameworks is emphasised. The relationships are so strongly linked to the people in the organisations, that even if the knowledge of those relationships is codified and stored they're difficult to capitalise. When conducting and managing co-operation the existence of these two parallel processes must be kept in mind: they're not substitutes, but rather complement each other. Naturally they compete and utilise the same resources, so the opportunity cost for ad hoc co-operation is the loss of a systemically planned, structured and managed collaborative effort and vice versa (this is, of course a simplification but will suffice - the idea is quite intuitive).

It must be understood, that some amount of co-operation will always be ad hoc in nature – sometimes the scope, duration or economical significance of the co-operation can be such that a formal co-operation relationship might be overkill. Also, the nature of academia and industrial organisations (or rather the people that work for them) prevents a structured approach: either policies are not enforced, they're not taken seriously or do not exist in the first place. Ad hoc co-operation is troublesome in the sense, that at least for the industrial counterpart the assessment of the co-operation can be very difficult. If an organisation cannot learn from and apply its knowledge from earlier experiences, the endeavours into co-operation with academic institutions will likely result to unsatisfactory performance without exception.

CONCLUSION

The managerial implications of the evaluation framework are quite clear. In the beginning of the co-operation the framework provides assistance for the leaders of the co-operative efforts on deciding how to proceed: what are the processes that have to be established, how should we measure and evaluate the co-operation and how the co-operation should be developed. When the co-operation has evolved from the embryonic stage towards a more mature relationship, the framework functions as an assessment tool for the organisations conducting collaborative efforts. As such, the evaluation framework should be applicable to co-operation conducting organisations regardless of their branch of business or academic orientation: the criteria consists of basic, relevant areas of activity that need to be managed, planned and executed fluently in order to achieve excellent results and continuous improvement.

The factors or attributes that are characteristic for U-I co-operation are the cultural differences between the partners, the complex and indefinite nature of outputs of the co-operation and the highly ad hoc-nature of operations. The first characteristic is easily explainable: before the change in the university law that made universities autonomous and responsible for their financing the fiscal responsibilities of universities were understandably less strict. The nature of academia in Finland was seen as a scientific community that

conducted research and teaching from its own bases, with little influence from outsiders or third parties. The new university law is effecting change towards more strict financial management, but universities are still quite distant from the industrial organisations in terms of organisational culture. The cultural difference also shows itself in the ad hoc nature of prior co-operative efforts: as the academia and industry have been traditionally seen as merely co-existing but being worlds apart, systemic and planned co-operation has been rare and only occasionally well done.

The success factors to face these attributes and close the cultural difference gap are related to needs and expectations, objectives and formalization, operations and outcomes as demonstrated in Figure 1. During the research, success factors identified were 1) Understanding the needs of the partner and clearly defining the offered services and products, for instance through productization 2) Defining roles, responsibilities and goals related to U-I collaboration both internally and regarding a particular relationship 3) An active role by the university in information sharing 4) Common perspective in collaboration 5) Proper resourcing by all parties involved in U-I co-operation.

Outputs from the co-operation can be indefinite and/or complex and usually difficult to measure. For example if co-operation amounts to educational interaction the quantification of the outputs is difficult for the industrial counterpart. Even the definition of the output is hard: is the result of co-operation (e.g. educational interaction through a practical case assignment) the solution presented by the students or for example the PR that the company gains among the students? Clearly the nature of co-operation affects the choosing of the indicators when conducting an audit. The indicators must be sought out so that they represent the end results as well as possible.

Through evaluation of U-I co-operation the identified success factors can be systematically analyzed, as suggested in Table 1. In this study the EFQM Model was utilised to form a comprehensive and coherent assessment approach. In the pilot discussion regarding a particular U-I co-operation dyad the framework was found to be meaningful and understandable. It was seen as a potential way to develop U-I co-operation from both the university and the industry viewpoint. However as stated in the theoretical review, an evaluation must start from the context: what is being evaluated and for what ends?

This study opened up lots of questions that should be answered regarding the use of EFQM criteria in the evaluation of co-operation between academia and industry. For the industrial participants the correct outputs have to be found out so that the effectiveness and efficiency of development efforts and the co-operation itself can be measured. The same applies to the academic organisations as well to some extent. The effect that the lifecycle in the relationship has on the usability of assessment frameworks could also be studied: does the lifecycle phase affect how the co-operation should be evaluated? These are the two interesting topics for further research that came up during this study.

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FINDINGS FROM EUROPEAN BENCHMARKING EXERCISES ON E-LEARNING: VALUE IMPACT AND GOING BEYOND

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ABSTRACT

Benchmarking is becoming a more and more commonly used method for quality assurance and enhancement in higher education today. The aim of this study was to explore the impact and value of benchmarking e-learning in universities. Two European benchmarking initiatives, E-xcellence+ through the European Association of Distance Teaching Universities and the e-learning benchmarking exercise through the European Centre for Strategic Management of Universities, were studied using an exploratory multiple case study method and cross-case analysis of the findings. The open-ended research questions followed the themes of: why the University joined the benchmarking project, opinions of the process after its completion and drawbacks within the project process. The findings indicated the value and impact of a variety of aspects of benchmarking e-learning on different levels, and stressed the need for a holistic and contextual approach as both benchmarking and e-learning are complex and comprehensive phenomena. This study also shows that benchmarking, in line with national and international quality boards/agencies, is a powerful tool for making improvements to teaching and learning. Some characteristics which may not be mentioned as often in a positive light are the intentions, i.e. the meaning of the benchmarking process as such. The involvement of individuals within the organisation creates an impact on both individual and organisational levels, not least through critical reflection. The meaning of the concepts 'rhizome' and 'becoming' used in this study have leant other and new dimensions to benchmarking. Thus, this study is not only relevant to management, but to philosophy as well.

Keywords: Benchmarking, critical success factors, e-learning

INTRODUCTION

Major changes are taking place in European higher education today, and quality in education and research is the key to supporting development and innovation. Universities are facing new challenges in the 21st century, as they are required to be competitive not just in terms of their educational, social, managerial and technological aspects, but they are also called to work globally as drivers for innovation and to contribute to sustainable development. In this environment, in parallel with institutional, regional, national and international demands and challenges, improving the performance and quality of universities has become more important than ever. At the same time, respect for individual students and accountability for the use of funding has to be taken into account, in addition to contributing to economic growth (European Commission, 2009; van Vught, 2008a, b). Enhanced quality and increased transparency are strong driving forces behind competition in education and research.

Benchmarking has become a more commonly used method for quality assurance and enhancement in higher education, as it deals with identifying gaps and making changes, but also with improvement and successful implementation of new procedures and schemes (Bacsich, 2009; Ossiannilsson, in press, 2010a, b). In a recent study, Ossiannilsson (in press) advocated the use of benchmarking as a method and a powerful tool for making improvements to teaching and learning concerning e-learning/blended learning in the 21st century, and to support improved governance and management in higher education. Ossiannilsson and Landgren (in press) showed in their study on three international benchmarking projects that the identification of success factors for e-learning and its implementation in the educational arena is of the utmost significance.

This paper focuses on the value and impact of benchmarking e-learning in higher education, which until now has remained a fairly unexplored area. Moriarty (2008) argued that although the literature on benchmarking is overwhelming, research and evidence on the value and impact of benchmarking is still missing. This study uses as points for departure the experiences of two European benchmarking initiatives; *E-xcellence+*, which was carried out by the European Association of Distance Teaching Universities [EADTU] (Ossiannilsson & Landgren, in press; Ubachs, 2009; Williams & Brown, 2009) and the *e-learning benchmarking* exercise, carried out by the European Centre for Strategic Management of Universities [ESMU] (Comba et al., 2010; Ossiannilsson & Landgren, in press; Williams & Rotheram, 2010). The research does not claim to focus on benchmarks, indicators, critical success factors or methodologies as such, and neither has this study been conducted using a special method for analysing impact. This study is based on multiple case studies, together with cross-case analyses, in order to contribute to the formation of a deeper knowledge and understanding of the value and impact of benchmarking e-learning in higher education and to go beyond.

THE CONCEPTS OF BENCHMARKING AND E-LEARNING

Benchmarking has developed into an essential tool for organisations, and is regarded as a vital component of good management practice. It is internationally respected, not just in businesses, organisations and management, where the concept came from, introduced by the Xerox Corporation, but also now in education and higher education (Moriarty, 2008). Camp one of the most frequently cited scholars with regard to benchmarking (cited in Ossiannilsson, in press; ReVica, 2009; van Vught, 2008a), explored the benchmarking process using five continuous steps: determining what to benchmark, forming a benchmarking team, identifying benchmarking partners, collecting and analysing benchmarking information and finally taking action. Moriarty and Smallman, (2009, p. 484) stated that "*the ´locus´ of benchmarking lies between the current and desirable states of affairs and contributes to the transformation processes that realise these improvements.*" Furthermore, Moriarty (2008) discussed the fact that although the literature on benchmarking is overwhelming, research and evidence on the value and impact of benchmarking is still missing. The criticisms of benchmarking are, according to Moriarty (2008), based mainly on lack of information, difficulties with implementation and a lack of theory. He stressed that benchmarking may require another definition, and that benchmarking is intended to be a means towards the end of achieving a more desirable

organisational state of affairs. Benchmarking may identify the changes which are necessary to achieve that end. The concept of change seems to be inherent in benchmarking. Benchmarking is, however, not just about change, but about improvement, or as Harrington (1995) put it, '*all improvements is* [sic] *change, but not all change is improvement*' (cited in Moriarty, 2008, p. 29). Moriarty continued by stating that benchmarking is not just about making changes, as it is more about identification and successful implementation. Therefore, he suggested a provisional definition: '*Benchmarking is an exemplar-driven teleological process operating within an organization [sic] with the objective of intentionally changing an existing state of affairs into a superior state of affairs*' (Moriarty, 2008, p. 30). The ESMU has worked with benchmarking in several projects in different areas within higher education. Their definition is: '*Benchmarking is an internal organizational* [sic] *process which aims to improve the organization's performance by learning about possible improvements of its primary and/or support processes by looking at these processes in other, better-performing organizations*' (van Vught et al*.,* 2008, p. 16)*.* As shown in the definitions above, benchmarking is very much a process designed to enhance quality, to identify gaps and to bring about the implementation of changes. Benchmarking initiatives are often conducted as self-evaluations, including systematic data and gathering information from predefined benchmarks, as well as formulating roadmaps. The goal of benchmarking is to formulate, together with other colleagues, strengths and challenges for the purpose of improvement (Ossiannilsson, in press; van Vught et al., 2008b). The benefits of benchmarking were expressed by the ESMU in 10 statements: '*self-assess institution, better understand the process, measure and compare, discover new ideas, obtain data to support decision-making, set targets for improvement, strengthen institutional identity, enhance reputation, respond to national performance indicators and benchmarks* [and] *set new standards for the sector*' (van Vught et al., 2008b).

Participating in a benchmarking process can potentially lead to change in the area being investigated. In addition, an increased awareness, both individual and collective, of the organisation itself occurs as a result of participation, which can be considered as a direct and substantial value. This awareness can often lead to reflections. Reflections are crucial and can even be a method for organisational change (Højrup, 2004; Ossiannilsson & Landgren, in press). Benchmarking is a rather new phenomenon in higher education, with regard to e-learning (Ossiannilsson, in press; Ubachs, 2009; van Vught, 2008a, b). Quality assurance, quality indicators, benchmarks and critical success factors for e-learning have neither been taken seriously nor incorporated into regular quality assurance procedures in higher education. These concepts have not been conceptualised, and are even sometimes taken as being synonymous. The concept of quality in e-learning has been discussed, considered and managed in a very disconnected manner, and it has not been embedded in learning and quality contexts (National Agency of Higher Education in Sweden [NAHE], 2008; Sonila & Stalter, 2010). Ossiannilsson also showed in earlier studies (in press, 2010 a, b) that there is a lack of experience of the value and impact of benchmarking in higher education.

The concept e-learning is by its very nature both open and global and has implications on a vast number of fields in daily life. In a digital world, we act and interact differently. We learn through all our senses; by listening, seeing, discussing and doing but above all through learning in day to

day life and through networks. Learning must therefore to a larger extent be organised and tailored individually and in a flexible way. In the discourse on e-learning, revolution and a paradigm shift in education are often mentioned in the same breath. Higher education is facing a series of challenges in order to participate in the development which is taking place within information and communication technology among other things but also to be able to accommodate more personalised and flexible learning processes. In the 21st century and the new millennium, learners exist in a digital world, and the e-phenomenon has to be embedded in all learning and educational activities and in order to push the boundaries (Bates, 2010; Bonk, 2010; Ehlers & Pawlowski, 2006; Ehlers & Schneckenberg, 2010; Johnson, Smith, Willis & Haywood, 2011). However, research has shown that respect has to be given to critical success factors in educational environments in order for them to succeed in the field of e-learning and to benefit learners, teachers and management (Ossiannilsson & Landgren, in press). McLoughlin and Lee (2008) explored success factors under the headings of personalisation, participation and productivity. Bonk (2009) went a step further, and expressed this concept as ubiquitous learning (u-learning), with the focus in the 'you perspective' on personalisation and the learner's rights and responsibilities. The EADTU emphasises within their *E-excellence Associates* label four success factors regarding e-learning, namely accessibility, interactivity, flexibility and personalisation (Ubachs, 2009). Connectivism is also considered as a concept which is essential to success i.e. that knowledge is distributed across networks of connections, and learning therefore consists of the ability to construct and traverse these networks. The concepts and success factors related to e-learning in the 21st century will surely change the current learning climate, and may have an impact on how benchmarking e-learning in higher education will be conducted in the future and the kinds of quality-related issues which matter (Ossiannilsson & Landgren, in press). Management is fundamental regarding the integration and implementation of ICT (Orlikowski, 2007; Sangra, 2008; Ubachs, 2008). New challenges for universities in the 21st century include bringing together all of the aspects of e-learning in a holistic framework, and perceiving these concepts in context (Ehlers & Schneckenberg, 2010; ENQA, 2010; NAHE, 2008).

THE EUROPEAN PROJECTS: E-XCELLENCE+ AND THE E-LEARNING BENCHMARKING EXERCISE

Two European benchmarking initiatives regarding e-learning were recently implemented. The first one was the *E-xcellence+* project, carried out during 2008 through the EADTU (Ubachs, 2009). The second was the *e-learning benchmarking exercise*, carried out during 2009 by the ESMU in collaboration with the EADTU (Williams & Rotheram, 2010; Comba et al., 2010). Both initiatives aimed to identify good practices with regard to e-learning by learning from other participants.

The EADTU (Ubachs, 2009) initiated the *E-xcellence* project in 2004 as part of the e-learning programme on behalf of their members, who had indicated that specific e-learning criteria were missing from the current quality assurance systems in place in Europe. The *E-xcellence* instrument was developed in co-operation with The European University Association (EUA), UNESCO and ENQA, in order to complement the existing quality assurance systems in higher education, rather than to interfere with them. The quality benchmarking assessment

instrument which was developed covered pedagogical, organisational and technical frameworks, with special attention being paid to accessibility, flexibility and interactivity. After the piloting phase, and under the *E-xcellence Associates* label, also personalisation was highlighted. The instrument was based on a manual covering 33 benchmarks on e-learning, across three main areas: management (strategic management), products (curriculum design, course design and course delivery) and support (student and staff support), with indicators relating to benchmarks, guidance for improvement and references how to achieve excellent levels of performance. In addition, assessors' notes were included to provide a more detailed description of the issues and approaches, as well as the tools, comprising the online instrument, the quick scan and the full assessment. *E-xcellence* was piloting during 2008 in the name *E-xcellence+* at local seminars (Ossiannilsson, 2010 b), and three universities carried out the full assessment, together with site visits. Several universities carried out the quick scan. Universities who conducted the full assessment on the level of excellence and underwent site visits, worked out roadmaps and committed themselves to carrying out the benchmarking process for e-learning in higher education every other year awarded the *E-xcellence Associates* label.

The *e-learning benchmarking exercise*, devised by the ESMU in co-operation with the EADTU (Comba et al., 2010; Williams & Rotheram, 2010), was carried out by nine European universities during 2009-2010. This initiative combined the ESMU's collaborative benchmarking approach through a comparison of the good practices of different universities with the EADTU's more individualistic approach, as mentioned above. The exercise started with the self-evaluated quick scan from the *E-xcellence+* scheme (Ubachs, 2009). Furthermore, two workshops with international experts were carried out, and roadmaps for improvement were designed by the partners.

MATERIALS AND METHODS

In order trying to explore a multifaceted phenomenon in depth, this study used an exploratory multiple case study strategy, as described by Yin (2003). A mixed-methods approach was applied, utilising a combination of qualitative data sources and integrated methods for data analysis (Yin, 2003; Creswell & Clarke, 2007). The data were mainly processed using cross-case analysis, with embedded and multiple units of analyses.

Respondents

The cases for the current study were selected from both projects: *E-xcellence+* (three respondents) and the *e-learning benchmarking exercise* (four respondents). One of the respondents from the latter project took part in both projects (Table 1). The respondents from the *E-xcellence+* project were chosen because they had been the first in Europe to be awarded the *E-xcellence Associates* label. For the *e-learning benchmarking exercise* all nine partners were invited to take part in the study, and five of them agreed (one agreed too late to be included in this study). In the following the respondents are called Alpha, Beta, Gamma, Delta, Epsilon and Zeta.

Table 1: Respondents involved in the benchmarking projects, EADTU *E-xcellence+* and the ESMU *e-learning benchmarking exercise.*

Respondents	*E-excellence+*	*e-learning benchmarking exercise*
A Alpha		x
B Beta		x
Γ Gamma		x
Δ Delta	x	
E Epsilon	x	
Z Zeta	x	x

Data collection and procedure

A case study protocol was worked out for the data collection procedure, and sent to the respondents in advance. The procedures were carried out so as to increase the reliability of findings and to maintain the chain of evidence, in line with the work of Yin (2003).

Existing survey data. Basic information about the respondents and their universities was found out in advance, and more information was gathered throughout the projects and their completion. The experts' reports from the benchmarking exercises were used as additional data (Comba et al., 2010; Williams & Brown, 2009; Williams & Rotheram, 2010).

Additional data for this study were collected through in-depth qualitative interviews or more as narratives recorded through Adobe Connect. One interview was carried out at the respondents' office (in this case, two respondents were both involved in the dialogue throughout the interview, which is also the way in which they work and teach) and recorded with a manual audio recorder. The interviews were typed out verbatim. Following the case study protocol, open-ended questions on the following main themes were used for the interviews:

- Why did your university joined the benchmarking project?
- What was your opinion of the process after its completion?
- In your opinion, where there any drawbacks within the project process?
- Do you have any additional thoughts regarding the involvement in the benchmarking project?

Data analysis and process

The existing survey data served to illustrate the case studies. Subsequently, during the analysis process, the data sources were analysed and integrated in order to contextualise the findings (Creswell & Clarke, 2007) and to elucidate the issues regarding the value and impact of benchmarking on e-learning in higher education. Each case was first analysed on an individual

basis, followed by cross-case analysis (Yin 2003). The qualitative data from the cases were processed in the following way. In order to obtain a general and holistic sense of the whole situation and to become familiar with the information in the cases, the recordings and the transcriptions of the in-depth interviews were repeatedly listened to and read through case by case. Listening to the material repeatedly reminded is of its meaning and content, but also gave a sense of the feelings and emotions contained in the narratives. The essential statements which had been made i.e. regarding the significant issues (natural units) were distinguished (Yin, 2003), the words were counted and a '*wordcloud*' was made. The text, case by case, was further condensed into units of meaning in relation to the respondents' expressions which served to highlight certain issues. Using this method ensured that the findings stayed close to the original data. The findings were aggregated or clustered according to key issues, reflecting the value and impact of taking part in benchmarking exercises. The analyses produced a summarised description of each case. The descriptions were intended to reflect the respondents' narratives and core experiences as closely as possible. The findings begin with an overview of the six cases, and then the findings will be presented case by case. Finally, a cross-case analysis, exploring similarities, differences and variations, will be presented at the end of the findings.

FINDINGS

Overview of the cases

The six cases and all of the respondents were from research intensive universities and so-called traditional universities which employ a blended approach. Three of them were in a process of transformation, in that they were merging universities and faculties, which was one of the reasons for participating in the benchmarking exercises. They were also in the process of formulating e-learning strategies. Three of the respondents were from universities in which e-learning was not separated from other forms of learning e.g. in policies and plans; however, they strongly emphasised new technologies and e-resources. The universities had well-known international reputations for e-learning and distance education.

In the report from the *e-learning benchmarking exercise*, the experts noted that participation in benchmark exercises always involves reflections on the part of the institutions involved on the lessons learnt and on new approaches and methods that the experience can be expected to bring. They suggested '...*integration of benchmarking into strategic planning and to conduct benchmarking exercises as a regular practice to support on-going organisational evaluation and retaining a competitive edge. Such a change agenda depends crucially on strong leadership to set clear directions and ensure their implementation. Highly-performing higher education institutions use a variety of tools, including benchmarking, to better understand their operations and progress towards increased performance*' (Williams & Rotheram, 2010, pp. 29-30). The experts also emphasised the important lesson that, in reality, the most important work in the benchmarking process actually starts when the benchmarking procedures are over and the implementation phase begins i.e. when changes are made with regard to human capital and implemented within the organisation.

In the report by Williams and Brown (2009), they pointed out, in addition to their findings from the site visit, some problems with international benchmarking. Some of the problems to be aware of are, for example, the fact that benchmarks often relate to more than one point and thus require a multi-faceted response and a team-based approach. An important issue which they noted concerns the interpretation of languages and linguistics, as well as cultural interpretations. In this case (*E-xcellence*), some benchmarks were also lacking e.g. library resources and student involvement, which were reported back to the EADTU. Williams and Brown (2009) also expressed that university campus courses would gain a great deal if they had the same transparency as the e-learning courses which were involved in the benchmarking process. They emphasised the importance of commitment at the management level in question when starting a benchmarking exercise, as benchmarking is about the implementation of results and (eventually) about change.

Alpha

Setting the scene. Alpha expressed two reasons for joining the project (the *e-learning benchmarking exercise*). One of the reasons was the desire to be part of one of the leading universities in the country within the e-learning arena i.e. to measure performance and to measure value for the money invested. Some ranking aspects were also considered. Another reason was to learn from others and to network for the purposes of further collaboration.
Being a multi-campus university creates challenges when it comes to staff and student support and the organisation of competence development schemes for both administrative and teaching staff in the field of Internet-based communication, collaboration and learning. At the same time, the multi-campus situation provides a natural driving force for the implementation of online technology that can help to save time and money on transportation between campuses.

Experiences. Alpha expressed and referred to the 10 summarised values which were described above (van Vught et al., 2008b). However, Alpha expressed that one of the most important values was possibly decision-making (i.e. during and after a benchmarking exercise, when an institution receives basic data and documentation). Other core values were perceived as an increase in awareness and understanding at the individual, collective and organisational levels. This is a sustainable value, as it involves the internal involvement of stakeholders within the organisation. Alpha also expressed that they had obtained both explicit documentation and also tacit knowledge and understanding which, due to the benchmarking exercise, became explicit. In addition, Alpha articulated that when one undertakes a benchmarking exercise with benchmarks to relate to, and holds discussions and interviews with stakeholders in an organisation, a collective picture of the situation is gained, which had a fairly large impact. Relationships were strengthened and team members became closer to each other. According to this participant, benchmarking is very much a question of involvement. This has resulted in spin-off effects in other projects within the organisation.

Alpha also expressed that one of the lessons learnt was that, during the benchmarking itself, a great deal of attention was devoted to gathering data, collaborative discussions, writing reports and formulating action reports with a lot of valuable help received from partners and experts. Conversely, less attention and support was gained during the implementation phase. Choosing stakeholders is another important issue, especially with regard to organisational learning, when the management needs to be involved. Alpha stressed the importance of commitment at the managerial level. This is probably the most important step in terms of organisational learning and development. Alpha felt that they came out relatively well in the benchmarking exercise, both in terms of their self-evaluation and also compared with the others. Accordingly, they learnt that they needed to look even more at their practices, and that improvement and consolidations could be made. Additional lessons were to consider a more constructive approach to learning in relation to e-learning, and that learning needs to be more deeply embedded in educational processes (i.e. to focus on how learning can be enriched by technology, rather than how technology can enrich learning). The fact that a new project had been created within the organisation with the aim of implementing some of the results of the benchmarking exercise was an explicit result. The values of the exercise, for Alpha, lay in extended networking with partners in the project, which had led to spin-off effects such as new projects and collaborations.

Alpha emphasised the importance of benchmarking as a method for quality assurance, as it involves self-evaluation and learning through and with others. Nevertheless, it requires a large amount of resources. Alpha put forward the idea that, in this context, it is probably of value to consider the content and the number of benchmarks. The drawbacks were that there were too many extensive benchmarks. Another issue was the linguistic sense, (the benchmarks was in English), but also in the translated form, there were different cultural interpretations among the partnership, but also within the organisation.

Beta

Setting the scene. One of the main reasons why Beta joined the project was the desire to be able to compare their e-learning efforts with those of other universities (the *e-learning benchmarking exercise*). Other reasons to participate were a need to gain new inspiration and insights, and also to learn from others in a spirit of collaboration. Beta is also a multi-campus university, and so the same arguments apply as in the case of Alpha.

Experiences. Beta expressed a whole range of benefits for their university. On a personal level, Beta learnt a lot about their organisation. An unexpected advantage was that they became aware of some new contacts, for strategic and practical work, even within the organisation. They also appreciated that they gained a good overview of what they were actually doing within the field of e-learning, as well as their strengths and weaknesses, what could be improved and what targets to set for the years ahead. Beta expressed this as follows: "*I think it surprised me how many different benefits on so many different levels in the organisation we actually gained. It was valuable to focus on the entire organisation and the future of e-learning in the university."* At a managerial level, the report was seen as important, as the university

came out with good results. This also showed that the resources allocated to the area of e-learning at the university were meaningful. It focused their attention on quality and the need to link e-learning to quality management efforts and to secure the widespread use of e-learning. Within Beta's quality organization and quality committees, they ensured the involvement of stakeholders and the dissemination of the project. With this level of organisation and commitment, it was easier to work with the lessons learnt. However, this process was not perfect from the very beginning, but they caught up in many ways during the process. From the start, Beta was under pressure to come out as one of the best universities in the partnership.

However, having gone into the process and learnt more and more about the organisation, Beta felt that '*the lessons you learn and the knowledge you gain in the process is perhaps the most valuable part of the benchmarking process'.* Of course, they were happy to point out their strengths, but also to record that there were some points which needed improvement, '*so you do not just rest on your laurels*'.

Beta also gave voice to the fact that the benchmarking process and results motivated people to developments, either by continuing with current developments or through innovation. Beta articulated that there were some limitations to the ways in which the benchmarks were formulated, in that they were pragmatic and depended on a certain way of looking at e-learning. Thus, Beta would recommend more open-ended questions and also more time to work through and revise the benchmarks within the partnership. It should be more like a joint effort and a collaborative approach. It was also suggested that time frames could be added for the further development of the process.

In addition, Beta emphasised that the successful areas within e-learning are mainly based on backup from top management, with clear and obvious visions and strategies throughout the whole organisation. The development of teachers' competences within the fields of learning and blended learning are also of the highest importance, together with pedagogical and technical support. Well-implemented e-learning platforms and tools are necessary. Knowledge sharing and the sharing of experiences both nationally and internationally are furthermore of the utmost significance. Finally, Beta expressed that funding should be provided for pilot projects or the most innovative projects within a certain area.

Gamma

Setting the scene. Gamma expressed three main reasons for participating in the project. First, they expressed that they were in the middle of a major merging process, and that they were also reducing the number of their faculties. Second, they expressed that there was a wide variety of e-learning standards and procedures at the university. Getting involved in the benchmarking exercise was therefore one obvious way in which to gain an overview of what was going on and a way to commence internal co-operation. Finally, their participation was a way for them to generate a roadmap and to get some new ideas, thanks to this international co-operation. They had no expectations regarding how well their participation would go or

whether or not they would succeed. Gamma is also a multi-campus university, and so the same arguments apply as were mentioned for Alpha.

Experiences. Gamma articulated that, in principle, benchmarking had a great deal of value and a significant impact, as suggested by van Vught et al. (2008). The value for Gamma was not so much in learning with and from collaborators, as in coming to know one's own organisation, especially as they were in the process of an extensive merger (so they did not have any working practice to relate to). Therefore, the main impact upon Gamma was related to values and lesson learnt regarding how they formulated themselves. Gamma expressed that '*benchmarking is a great tool to point out flaws, to explore and spot missing areas and to raise attention. It is also a good opportunity to work with best practice and it is also a method to create inspiration*'. Gamma is in a phase of reorganisation, and due to this they had many ideas relating to the processes of innovation. Gamma suggested that benchmarking ought to be mandatory for universities, either on an annual basis or every other year. Benchmarking should take place in different areas in order to enhance quality and with the aim of being in the frontline. In this case, benchmarking is a great method for educational movement; enhancing quality and working processes in order to relate to best practice etc. in a more structured and more professional manner. Universities need to have benchmarks and indicators in order to speak the same language. In addition, benchmarking allows universities to extend their networks and to collaborate on setting up new projects or bilateral agreements (spin-off effects).

Gamma expressed some pitfalls of benchmarking, which of can be turned into opportunities as and when they became visible. Some pitfalls are language and cultural differences, but also the question of how to set benchmarks e.g. in this case, they were rather unfashionable, so Gamma had to go above and beyond in order to connect to their area and context. In order to improve, it is essential to consider cultures, such as the university's own culture but also international perspectives. The disadvantages also include that benchmarking is time-consuming and demands focus. However, Gamma expressed that if one spends time and focuses on the work in a benchmarking exercise, one will get more out of it and therefore gain more from it: '*What comes in goes out*'.

Gamma also stated that they now focus more on learning and how students interact with IT and the social media in their context. This raises questions about the contextualisation of learning and education. Therefore, in the event that a benchmark exercise should be set up again, they will consider these phenomena to a greater extent.

Delta

Setting the scene. Delta expressed that as they were selected to take part in the benchmarking project (*E-xcellence+*), they naturally appreciated the opportunity and wanted to join in. They were also curious with regard to obtaining an awareness of how far they had reached, even though they had established an international reputation many years ago, and had many international students enrolled. Second, they saw the advantages of the process, such as

obtaining an internal awareness and knowledge about their own organisation. The third driving force was the fact that there was an opportunity to attain official international recognition; this, of course, was a motivating factor. Another motivating factor was the future situation of the university, as they from 2011 have to charge tuition fees for students outside Europe. Competition will thus be more explicit, and there will be an even stronger drive to ensure that students get what they pay for. Being internationally distinguished is, in this context, very significant.

Experiences. Delta was the first university in Europe to be awarded the *E-xcellence Associates* label as a concrete recognition of the high quality of their e-learning programme. As a result of this, the level of their national and international collaboration, as well as student recruitment, was increased. The real impact of this will first be noted in a few years when the first students (who are paying tuition fees) enroll and they are asked why they chose this programme instead of others. In addition, students who are already enrolled are impressed and appreciate being enrolled in a programme which has been labelled as excellent. They have also articulated a positive response to the educational culture and level of professionalism they have experienced. Delta also emphasised that they had received an increased level of recognition for their work at different levels within the university, which has resulted in spin-off effects.
Delta stated that, in terms of their positive experiences, they have had the opportunity to undertake the benchmarking and internal processes, which increased their understanding and knowledge. To have the chance to reflect and to share within the centre, but also with colleagues within the university, was very valuable, and made their work more effective. In addition, it was valuable to perform a self-evaluation, as well as the documentation and the experts' report. This was also a way for Delta to gain an awareness of the areas in which they fall short. In addition, they had opportunities to review and improve their routines.

Thus far, they have not been involved with or taken part in the *Excellence Associates* club, but they will in the future and can see the advantages of such a network. The roadmap that they worked out has served as an inspiration and as a driving force. It is not a formal action plan, but a working plan and an inspirational document. They expressed that they have either worked through some of the actions or at least considered them. It is an honest document, referring to what they ought to do, considering time restraints and financial opportunities. They articulated that, during the process, they benefited from support and commitment from the management team, and they also stated that, without this support, it would be more or less impossible to carry out changes or improvements in relation to the benchmarking exercise. Other issues were that the exercise was so time-consuming due to the need for data gathering, internal discussions and analyses that support and commitment were needed. They expressed that they had experienced continuous support, even now the real work has started with the implementation and transition phase.

Delta emphasised the importance of involvement and teamwork during the process. The benchmarking exercise was as such also important due to the need to '*attract attention, gather and spread information and engage staff and students (three core concepts)*'. Delta articulated that the benchmarks were comprehensive, but maybe too comprehensive. On the other hand,

this contributed to discussions, interpretations and the development of knowledge within their own educational culture and context. If Delta were to undertake the exercise (or a similar exercise), again, they stated that it would be valuable to estimate time requirements, and probably also to have a more explicit overview of the process. The drawbacks of the exercise, when one is sensitive to them, can be turned into opportunities. Another issue is whether the university could or should market and raise awareness of the benchmarking process to an even greater extent.

Epsilon

Setting the scene. Epsilon indicated three incentives for their participation (in *E-xcellence +* and the *e-learning benchmarking exercise*). First, they expressed that they wanted to obtain an awareness of what was state-of-the-art in the area. Second, they wanted to learn from others and to obtain an awareness of their progress in the area in an international context. Finally, they expressed that participating was a way to obtain insights and knowledge with an eye to the future.

They also expressed that their participation was a way of gaining both internal and external processes. They stated that benchmarking is an optimal method for raising awareness and understanding of what is going on, both internally and externally. Both advantages and disadvantages become explicit, but primarily and most importantly, potential areas for success and where quality can be enhanced become visible within the common understanding in an organisation.

Experiences. Epsilon expressed having found the exercise to be valuable both internally and externally, and that lessons can be learnt in and through both dimensions. For Epsilon, the projects had been extremely valuable. Benchmarking is a way of watching what is happening in the surrounding world. Regarding Epsilon's participation, it can be stated that they found it to be valuable on several levels; within departments, on the university management level, and on national and international levels. One example which was articulated several times in the in-depth interview was the fact that a new programme is going to be set up in collaboration with several other universities in the country. With this programme, there is a need for high quality work to be carried out with new technologies, not just for the purposes of content and inter-university collaboration, but also to create a model and to become part of an IT society in the 21st century. Even within other areas of the university, schemes are being implemented as result of the benchmarking projects in combination with the current discourse in this area.

Epsilon articulated that they found it interesting how many outstanding things had happened throughout their faculties and departments; it seems likely that these things have happened due to the fact that Epsilon is a decentralised university. They therefore expressed that freedom, enthusiasm and development on demand are crucial for a reflective and growing organisation. The key is not always efficiency, as sometimes quality enhancement is more important. Both bottom-up strategies and top-down strategies require flexible methods. Benchmarking helps universities to choose a direction. At a research intensive university, where

the teachers and programmes are at a variety of levels in terms of IT proficiency, from early beginners to those who excel, there are a variety of demands and requirements; however, there needs to be something for everyone, even at a central organisational level. The most important thing at a large university is to develop maturity and '*teaching environments to learning environments to web environments and also that it* [e-learning, new technologies, social media etc.] *is embedded in* [the] *curriculum*'. This journey has to take time. An awareness of maturity is of great importance, as if an organisation is immature, then no development will happen. There needs to be maturity, at both individuals and organisational levels. Each faculty/department has their own structures for dealing with demands and cultures. This is good. In addition, one has to make choices, and one has to be familiar with e-learning and technology development. When maturity has been reached, co-ordination can begin.

The fact that two of the programmes at Epsilon were awarded the *E-xcellence Associates* label indicates that they have been recognised both internally and externally. For the programmes that were awarded the label and already have large groups of international students from outside Europe, this award is very valuable and will have a significant impact as they are facing a new situation regarding tuition fees for students from outside European Union. Of course, this is due to other programmes as well. The *E-xcellence Associates* label supports the entire university in its strategic work towards achieving consolidation, internationalisation and distinction, as universities are striving to be world class. Epsilon stated that they valued all of the documentation which had been a part of the benchmarking projects, which they will now use for other purposes. One example is that when the National Agency for Higher Education conducted a survey of distance education in the country (Sweden), then the benchmarking reports supported the documentation required for this survey to a large extent.

Epsilon stressed the fact that e-learning needs to be user-friendly, integrated and embedded into courses and educational arenas. Epsilon stressed further the importance of freedom in a large organisation, as creativity grows and things happen when there is freedom.

Zeta

Setting the scene. The main reason why Zeta chose to participate (*E-xcellence+*) was to ensure the quality of its education and courses and to provide evidence that these were of the highest possible quality. The main reasons for this are due to student rights and student satisfaction. Other reasons were of both an internal and external character. The internal reasons were a desire to raise awareness of advantages and disadvantages concerning range, support and implementation of the e-learning arena at Zeta, and in addition student satisfaction, and through the process find gaps for possible improvements.

The external reasons were mainly a desire for international co-operation and networking, but also an attempt to learn from and through others. As benchmarking is a form of self-evaluation, it is more honest and the motivation to make changes is thus higher, as any criticism tends to be more constructive. There were also other reasons, such as the fact that each member of the staff including the students need to feel appreciated for their work. It is also important to note

who the actors are who initiated and took part in the benchmarking e.g. in this case, the benchmarking was initiated by the EADTU, the National Agency for Higher Education and the university itself. The chance to attain the *E-xcellence Associates* label was also an incentive to join the project.

Experiences. Zeta expressed that through the benchmarking project, advantages and disadvantages concerning range, support and implementation of e-learning became visible and ideas for changes were considered. The fact that Zeta earned the certification and the label was, of course, very encouraging, and the label demonstrated that the university had been recognised internally as well as in international collaboration and networking. In addition, more students are being recruited. This is, of course, a triumph, especially when the university was co-operating with countries that tend to distrust distance education. However, Zeta expressed that they might be able to market distance education to an even greater extent, but they already have more than enough students (i.e. more than they get paid for). Naturally, this was an occasion for self-evaluation and this influenced all staff and their work. Of course, the label as such is not as important as the knowledge and understanding of the work which the university is doing, as well as an awareness of their shortcomings. Nobody is happy with just the award itself. Zeta, therefore, articulated a very humble attitude towards its recognition. However, two of the leading staff awarded the university a prize for excellence in teaching and pedagogy in the following semester.

Zeta stated that the roadmap served as inspiration and not as a dogmatic document. Some of the actions have already been taken and some are being considered, due to limited time and resources. They expressed that they have been supported by the university, although perhaps not always at the closest administrative level i.e. the faculty level, probably due to a degree of mistrust, as they are too far ahead and too innovative in their course development and delivery. Maybe this had been the fact anyway, if they had been innovative and therefore succeeded in other areas, they would have experienced mistrust there as well.

Concerning the benchmarks, Zeta expressed that they were particularly extensive and that they worked in teams in order to get the staff and students involved. They used micro and mini meetings to go through everything and to discuss different aspects of the process. Zeta gives voice to the idea that one of the most important issues is flexibility at all levels and dimensions in any attempt to satisfy students. The ultimate goal is to satisfy students, and they frequently demand a high degree of flexibility. Satisfied students are important quality indicators. Flexible and boundless education with regard to pathways, time (even starting time), free resources, flexible materials/resources (texts, audio, video) etc. is of paramount importance and forms the foundation of the programme. Student evaluations have also shown that this flexibility is crucial.

One explicit impact was an inspection of the learning platform and the overall university administrative system in order to make communication more flexible. Zeta stated that when e-learning programmes begin, the most important aspect seems to be the learning dimension. This is natural, but when courses are scaled up, it is crucial that administrative systems communicate well.

Thus far, Zeta has limited experience of the *E-xcellence Associates* club, due to limited time and human resources. Obviously, such initiatives are of the highest importance. Zeta's final comment was that universities which are striving for the highest quality in an international field should certainly consider benchmarking.

Cross-case findings

Overall, the findings indicated many similarities between the universities, but also differences, or rather different ways of expressing experiences across the cases. The cases illustrated how different aspects interact to a varying extent and indicated the value and impact of the international benchmarking exercises which were conducted. In the section below, some of the key areas are summarised.

Internal processes and involvement

The benchmarking allowed the teams to maintain their focus. Involvement and shared responsibilities in the work with benchmarking enabled not just the benchmarking itself, but also contributed to commitment and appreciation among the co-workers within the institution. The fact that advantages and disadvantages in the field of e-learning became explicit supplied the motivation to make the changes which led to the impact of the scheme. In addition, the fact that the exercise was mainly a self-evaluation motivated the institutions to examine even negative issues, which often could be turned to challenges.
In addition, the solid documentation which was collected, as well as the knowledge and institutional awareness regarding e-learning was important and led to a significant impact. The institutions gained a lot from the solid work with its transparency, which could even be used and valued in other contexts. The awareness of the infrastructural support for e-learning, which was one of the results of the benchmarking exercise, was made explicit and this led to closer collaboration between the infrastructural units in question, as well as further collaboration with other faculties and departments, for example within pedagogical areas and e-resources. Additional benefits were clearly expressed regarding teamwork, creating a dialogue, policy making, quality assurance and transparency within the organisation.

Quality enhancement

Benchmarking is an advanced method, but the cases have indicated that it is quite easy to use with explicit opportunities for self-reflection. Even though certain steps have to be taken, one can set the structure within the partnership as either a smaller or a larger exercise; one can also define the benchmarks, partners and the time schedule. Nearly all of the cases reported that enough time and support was allocated during the project period. However, they emphasised that they misallocated time and support for the reflection and implementation phases. This process needs to be followed by reflections on the lessons learnt, which can provide incentives for further development in the institution. This may involve changes in structure, organisation and resource allocation, which may require strong leadership at all levels. Furthermore, the

importance of integrating benchmarking processes as a natural part of strategic quality assurance work was emphasised. The value of continuously following up earlier benchmarking exercises as well as committing to new projects was highlighted. All of the respondents agreed on the value of benchmarking as a method for quality assurance.

Management and commitment

The cases showed, to a significant extent, the importance of full support and commitment from all levels of the management team during the whole benchmarking process. Such support is necessary in order to maintain the focus on the project, to allow staff and students to be involved, to work in an interdisciplinary manner and award status for the ongoing work and dissemination during the process, but most of all with regard to data gathering and reports i.e. the implementation phase, if changes have to be made. In these cases, several departments were involved in full. They were therefore able to focus on and discuss common areas and processes, creating togetherness, trust, commitment and involvement. This will certainly contribute in turn to enriching the future employment situation and potential areas for development.

Collaboration and networking

When taking part in benchmarking exercises, universities have the chance to meet other institutions that are facing the same challenges as themselves. There are opportunities to approach one another, to learn from best practices and to take part in joint discussions on how to handle challenges. This can evolve into continued benchmarking on a smaller scale, where two or more universities from the group collaborate and formulate new benchmarks. Such new benchmarks can help the institution to improve important areas and can play a major role in continuing quality assurance efforts. On a more practical level, the knowledge exchange between benchmarking participants can lead to mutual inspiration and can help the individual universities to understand and handle topical issues within the field of e-learning.

In the benchmarking exercise, it became apparent that each university possessed best practices within certain areas that were of importance for all of the universities. These areas included pedagogy, technology, strategy etc. In the benchmarking exercise itself, there was unfortunately no time to study the best practices of the other universities in depth. However, the exercise itself provided a good overview of the strengths of each individual university. Mutual trust and understanding has been gained, and future activities such as joint applications and agreements for further co-operation will naturally be established. A network has come into being, in which participants can use each other as experts when knowledge of a certain topic is needed.

Cultural issues

As this was an international benchmarking initiative, English was the chosen language. All of the cases raised a problem with this. It was not just the language and linguistics as such, but also

cultural aspects of the language and how it is used in different contexts. The benchmarking was mainly carried out in teams, and even within the teams there were differences in how certain concepts were understood. Another issue was the somewhat old-fashioned concepts regarding e-learning. Nearly all of the cases work within a blended mode context. In addition, nearly all of the universities in question are decentralised, and thus there was not only one way of acting and performing.

Attitudes

Through the in-depth interviews, all of the cases voiced their enthusiasm and positive feelings regarding the exercise itself, but also regarding the methods. It was, for example, noted that during a comparatively short time, many lessons had been learnt, both about the institution themselves, but also about wider perspectives including other universities and the surrounding international context. Furthermore, it was articulated that they had also gained a deep understanding and knowledge in the area of e-learning through the benchmarks and indicators, areas which to some extend seemed to be tacit knowledge. In addition, they expressed their enthusiasm and interest in continuing to work, or as they put it, they had the energy to tackle future challenges. All of the respondents expressed that it would be useful to carry out the exercise again, but maybe on a smaller scale with time to define their own benchmarks in a more useful way.

DISCUSSION

The integrated case study findings provided critical information on the value and impact of benchmarking in higher education. Most importantly, this study showed the complexity of the value and impact of taking part in such exercises. The complexity of benchmarking e-learning in higher education is based on the fact that values can refer to either immediate or more long-term values. Furthermore, these values can apply to different aspects and different levels, and to both individuals and organisations. Moreover, some effects take years to evaluate.

One contribution of this study to our present knowledge and understanding of benchmarking as a method seems to be a recommendation that time, resources and maybe even the use of experts and/or co-partners is allocated for the implementation phase, as this is an important step in the benchmarking process. All of the respondents in the study clearly emphasised the lack of support they had received afterwards. Another contribution is the apparent importance of commitment from managerial levels. In the event that structural changes or other changes have to be made, resources will probably need to be allocated or re-allocated, and due to this it is extremely important to have commitment from the leadership. This works both ways; if the institution produced as ‘good result’, it is essential to communicate and market such benefits, internally as well as externally.

We are facing a paradigm shift within the 21st century, and e-learning as a phenomenon was considered among the respondents to have a very broad meaning. Therefore, the learning dimensions were emphasised. Changes in technology have to be considered in education, even

through a social-contextual approach. This study shows, therefore, that benchmarks must be chosen with care and that linguistic, cultural and contextual issues have to be taken into account. Even if this study did not aim to focus on benchmarks as such, critical issues within the area were articulated, in accordance with the success factors described by the EADTU (Ubachs, 2008) and Ossiannilsson and Landgren (in press). The need for flexibility in all of the concepts and dimensions was clearly highlighted. Even the structure of the partnership is crucial, as are similarities and/or differences within the partnership. How to choose benchmarks that provide direction is one of the aims within the benchmarking process. Trust, honesty and courage are of the utmost importance in benchmarking processes for fruitful and sustainable work and collaboration. As mentioned above, there can be pitfalls, but awareness and thoughtfulness can turn them into challenges.

This study showed that benchmarking is about change. It became explicit that the process as such and the involvement and collaborative learning at different levels within units as well within the partnership was of utmost value. In this study, the findings on the value and impact of benchmarking as described by the respondents were close to and in accordance with the 10 good reasons to conduct benchmarking as described by van Vught (2008b). Some more critical issues were also touched upon, such as the significance of the first and last phases of benchmarking; the identification and implementation phases. Furthermore, the value and impact of tacit knowledge (Elliott & Stemler et al., 2011) were explicitly expressed. However, they were not only expressed; the possibility of sharing this tacit knowledge, as well as knowledge and experiences, was articulated as a possible impact. The case studies indicated the importance of support and management when making changes, as Sangra (2008) also argued. Contributions to the transformation processes that realise improvements require commitment, but also reflection. Through the cross-case analysis, the respondents experiences in this study indicated that a process of philosophical interpretation is required, and that there is a need to modify the theoretical assumptions concerning benchmarking. Høyrup (2004) argues that there is a need for a learning organisation to reflect, but he distinguished between reflection and critical reflection. He emphasised critical reflection in particular as one of the core processes of organisational learning. He stated, moreover, that critical reflection was necessary on both the individual and organisational levels. Critical reflection includes social, cultural and political aspects and concerns the *why*, *the meaning*, rather than questions about how to act or perform. The meaning of reflection and the importance of reflective practices for change was also clearly expressed in the study. Another dimension of critical reflection can be seen through Deleuze's concept of 'becoming' (cited in Giger, 2010). Becoming share the common meaning of becoming which even is true in this context. Thus, the process of becoming is about changes, just like benchmarking is about changes. Becoming, as a more philosophical concept, has something to do with becoming us as individuals. The rhizome concept, also put forward by Deleuze & Guattari (cited in Giger, 2010), was described in brief as connectivity and multiplicity. Both concepts are new dimensions which are valuable for understanding of benchmarking and organisational changes.

CONCLUSIONS

Benchmarking is a powerful strategic tool used to assist decision-makers to improve the quality and effectiveness of organisational processes. Since the results from benchmarking of e-learning within higher education have not been documented to any large extent until now this research contribute to a deeper understanding of benchmarking, quality work and quality enhancement of e-learning in higher education and to go beyond, although it does not aspire to be exhaustive.

This study showed that the quality of e-learning has to be considered and must be embedded in suitable contexts. In the case studies, the respondents expressed that the benchmarking process had significant impacts i.e. the power to make changes. The results indicate some key areas which have to be considered in benchmarking processes, areas as internal processes and involvement, quality enhancement, management and commitment, collaboration and networking, cultural issue and attitudes. Other issues which have to be acknowledged are the choice of objectives, how the benchmarking is organised and set up, how to choose partners and how to choose benchmarks. In addition, how to generate commitment and allocate time and resources during the entire benchmarking process, including the implementation phase has been emphasised in certain cases. Some characteristics which may not be mentioned as often in a positive light are the intentions, i.e. the meaning of the benchmarking process as such. The involvement of individuals within the organisation creates an impact on both individual and organisational levels, not least through critical reflection. The concepts of 'rhizome' and 'becoming' used in this study have leant other and new dimensions to benchmarking. Thus, this study is not only relevant to management, but to philosophy as well.

For benchmarking, as for all quality assurance work, follow-up is of central importance**.** This is why, after participation in a benchmarking project, extensive work is undertaken to reflect in different ways on what has been learnt and to use this information for further development and change in the higher education institution concerned**.** The gains from benchmarking projects are numerous**.** One benefit that should be specially emphasised is the collaborative learning process**.** This happens on different levels, both within the various organisations and between the participating cooperative partners. Through the opportunity to find out about one another's best practice, but also through confirmation of one's own activity, good conditions are laid for further development. In addition, cooperation and contact during the course of the project can give *spin off* effects on the local, national and international levels even after the project has been concluded.

In discussions on e-learning higher education, challenges as revolution and a paradigm shift are often mentioned in the same breath. Results from the projects make it clear that complexity and a holistic perspective should characterise high-quality e-learning/*blended learning*. An approach that involves all the various success areas together is essential for students who are studying their programme via the internet and who wish to be in a position to take active responsibility for their own learning. Both strategic development (*management*), course design and implementation (*products*) and student and lecturer support (*services*), together with the consequences these have for borderless learning, globalisation and sustainable development,

should be taken into account in the planning, implementation and evaluation of e-learning in higher education. Transparency with regard to structure, materials and resources among other things, is also emphasised as significant for quality in the field of e-learning. The challenges for higher education no longer consist in doing what they already do, just with the help of digital media. Instead, they must change and develop the educational culture so that students can study, work and live independently of time and space in an extended digital environment and with the diversity of resources from the entire world at their disposal. In this way, higher education contributes not only to sustainable development but also to boundary-crossing activities.

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PRODUCTIZATION OF UNIVERSITY SERVICES

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ABSTRACT

The constantly tightened competition and shortened life-cycles of technologies have driven firms to co-operate with educational institutes and universities. Concurrently the changing economic situation and emphasizing of the third mission of universities as a social influencer have driven universities to collaborate with firms. Co-operation between industry and universities has been increasingly discussed and the literature emphasizes the importance of this line of research, but the development of co-operation has been faced many challenges e.g. unclear and undefined service offering of universities, the missing of mutual content and structures.

In this research we suggest how productization can be used to improve university-industry co-operation. Productization refers to analyzing the needs of the customers, designing the product and developing the ability to produce it so that offering and results could fulfil the expectations of the customers. Through the productization of university services several benefits can be achieved: better quality and management of services leads to more stable, effective and manageable processes; the communication with customers is much easier and customer perspective can be taken more deeply into account, and services are partially standardized and partially customized. As a managerial implication is proposed that university should increasingly make an effort to productization of their services in order to achieve and increase both side benefits and value.

Keywords: productization, U-I co-operation, university services, university-industry co-operation, university-industry

INTRODUCTION

Intense global competition, rapid technological change and shorter product life-cycles have transformed the current competitive environment (Bonaccorsi & Piccaluga, 1994; Santoro & Chakrabarti, 2002). Organizations have faced increasing challenges in order to sustain their long-term success and prosperity relying solely on internal resources (Santoro & Chakrabarti, 2001). To meet those challenges, universities and firms have started to establish more formal and effective co-operations instead of informal methods Mead et al., 1999).

Co-operation between industry and universities has been increasingly discussed and studied. The necessity is commonly known, because the economic structure of universities has changed and it has increased the gap between public funding and research expense (Bonaccorsi & Piccaluga, 1994). Universities have started to expedite and prefer a variety of diverse collaborative by more formal structures which have brought about explicit leadership for knowledge and technology transfer as well as two-way knowledge flows (Santoro & Chakrabarti, 2001). For firms, universities are important and natural partners and a source of new knowledge, technology and procedures (Confederation of Finnish Industries EK, 2009; Santoro & Chakrabarti, 2002). Suggestion how those relationships should be established and maintained have been proposed, but U-I co-operations have traditionally been informal, casual and based upon personal contacts (Mead et al., 1999). As a consequence of those, exchange between educational institutes and industry has been undefined.

In service business, productization is the natural predecessor for successful market entry and it needs to be done before services become successful (Simula, Lehtimäki & Salo, 2008). Success in productization will create increased demand for services, which makes it one of the key factors behind success (Flamholtz & Aksehirli, 2000). The main output of productization is to bundle offerings and deliveries together in well-defined packages so that the value that the expectations of the customer are better fulfilled. Productization creates a positive signal that the service provider understands customer requirements and is willing to respond accordingly (Grönroos, 1984; Simula et al., 2008). The strength of universities lies on the wide variety of services they can offer and productize; different kind of business-to-business (B2B) services e.g. consultations, research projects as well as public services like education. Therefore the objective of this paper is to examine how can university-industry co-operation be enhanced through productization?

To achieve that task, firstly the paper will take a look on the key features and elements of U-I co-operation. Then the theory of the productization and the benefits of it will be elaborated. The challenges of U-I co-operation that can be solved through productization are also discussed. The empirical part illustrates a case study which concentrates on the productization of universities' services. The phenomenon has been examined from the perspectives of the University of Oulu, the department of industrial engineering and management (DIEM) and their main partner. In the concluding part, the answer to research question and the discussion about the findings, implications and further research ideas will be presented.

UNIVERSITY-INDUSTRY CO-OPERATION

New technology and knowledge development on intra-organizationally has become increasingly difficult in more intensive competitive markets and it has increased the needs of firms for inter-organizational co-operation (Barnes, Pashbym & Gibbons, 2002; Santoro, 2000). University-industry co-operations can be seen as a powerful way to increase both side benefits. In addition, U-I co-operations have usually made a positive contribution to innovations and help to return the investments of research and

development (R&D) (Balconi & Laboranti, 2006; D'Este & Patel, 2007; Santoro & Chakrabarti, 2002).

The forms and objectives of U-I co-operation

The success of co-operation is always a sum of many things and requires investments by all participants. By U-I co-operation: Firms are trying to gain competitive advantage and addressing business growth, whereas universities are trying to fulfil their mission to create new science and offer education.

U-I co-operation can be divided into five different categories: research support, knowledge transfer, technology transfer collaborative research (Santoro & Chakrabarti, 2002) and educational interaction. Basically research support is only one-way co-operation which is served by firms. Also knowledge transferring includes some one-way co-operation, but collaborative research and technology transfer always insists on at least two participants.

Nowadays "blind" research supporting and financing is very rare, because firms want answers to specific problems or possible future technologies. According to a few Finnish surveys (e.g., Confederation of Finnish Industries EK, 2009; HSE yrityspalvelut, 2009) corporate presentations and infobits have been seen one of the most important ways to co-operate. Those give aspects about firms and their business, but also opportunities for students. By that firms are able to be more attractive employer and are able to recruit highly motivated and educated employees and interns. These internships are very important to both universities and firms.

Knowledge transferring contains recruiting, consultations, personnel exchange and information sharing. In addition, such interactions can be both formal and informal. The objectives are intangible, because knowledge transfer is aiming on spreading and sharing of information. According to Santoro and Chakrabarti (2002), knowledge transfer helps universities and firms train students in state-of-the-art techniques. Knowledge transfer is long-term co-operation, which is many times looking for something new in ancillary fields and areas. Therefore multi-organizational consortia are typical.

The next two categories are technology transfer and collaborative research. Those categories consist of almost every possible way to do research and new science. Many times this is "invisible" for those who are not working with universities. Technology transfer and cooperative research are probably the most important or at least the most concrete groups for firms. By those universities and firms are carrying out more specific and coordinated projects, which have an agenda and a formal network (Santoro & Chakrabarti, 2002). The objective of such projects could be the service modelling where university and participant(s) try to create new business opportunities.

The last group is educational interaction, which is added to entail the educational mission of universities. For students this group is probably the most interesting because it provides possibility to have current and actual cases to solve. Cases can be little

problems, which solving can also benefit firms (Mead et al., 1999). Those kinds of little researches by students are highly appreciated in Finnish firms (HSE yrityspalvelut, 2009).

Visiting lecturers are a very good way to keep students interested in topics and real world examples always give objective aspects to those. Visiting lecturers can also be firms' personnel, who are looking or studying for updating education. Possibility to updating education is one of the most classical and appreciated form to co-operate (HSE yrityspalvelut, 2009). Further education can be short-term, for example some basic courses. However, it can also be long-term, which is aiming to some degree, for example MBA or doctor's degree.

Despite forms of co-operations, it can be generalized that co-operations and relationships, especially long-term, are based on trust, good experiences and breadth of interactions, because customer satisfaction and revenues are common evaluation categories (Bruneel, D'Este & Salter, 2010; Mead et al., 1999; Santoro & Gopalakrishnan, 2001).

The benefits and challenges

Co-operation must be beneficial and valuable for both firms and universities. Mead et al. (1999) have stated: "there are significant benefits derived from the interaction of universities and industry to meet the professional development education and training requirements". Universities and industry can be seen as complementary and beneficial partners. Because of that, U-I co-operation offers so more benefits than possible problems and challenges. One of the most important things to remember is that co-operation must always ensure both side benefits in order to be long-term and successful. It is also good to remember that the mission of universities is not to serve industries' instant needs, but do the basic research.

U-I co-operation serves multiple benefits and there are many reasons to build these relationships. For example, firms can access to highly trained students and new technologies; increase their resources; enhance firm's image and growth in business. The competitive advantage is usually achieved with lower costs of R&D when co-operations are carried out with universities. In contrast, universities can obtain research funding, the latest knowledge and practical problems for students and researchers. In summary, in order to do basic research and be able to create new design and concepts, university researchers must be familiar with industrial technology and firms have to be capable of creating relationships with universities. Table 1 illustrates the most important benefits to both university and firm.

Sometimes value or benefit is very difficult to measure or identify, because always the outcomes are indirect or intangible. In addition, different forms of co-operation can be related to each other or some co-operation can lead to another. Many times firms and universities have a strategy which is aiming on all-round benefiting in many different sectors (HSE yrityspalvelut, 2009). However, it is not a problem, because sometimes the objective can be somewhere else than in tangible outcomes. Such objective can be, for

example, in networking or a better employer image. For those reasons, all the main forms, which were introduced in the previous chapter, are absolutely important.

Table 1: The benefits of U-I co-operation.

University	Description
Funding and support	Financial funding, gifts, upgrading/building of laboratories.
Information and knowledge	Current and new information about on-going challenges and areas of interest.
Research projects	Short- and long-term researches: solving of immediate business problems or seeking for completely new knowledge.
Development of know-how	Better understanding of a business world. Combining of theory and practice.
Networking	Wider and better contacts to the industry and to a business world.
References	Increased visibility among firms and in the media.
Industry	
Reduced costs of R&D	Universities are able to execute R&D projects more cheaply than private firms.
Competitive advantage	Competitiveness by products, services and procedures.
New innovations	Access to the latest knowledge in an early phase, and exploding of it in the R&D projects.
New employees	Academic researchers and graduates.
Employer image	Co-operation and interaction with universities and students.
Networking	Possibility to discuss and co-operate with other firms and universities.

Most things are beneficial, but there are also some challenges to solve – especially in the implementation. Probably the most natural reason for casual and non-systematic U-I co-operation is the lack of workable structures (Confederation of Finnish Industries EK, 2009). Clear contact channels or content are missing, because co-operations have used to be bonded to some specific people, and therefore the needs and offerings don't always meet and firms seemed to find suitable partners elsewhere (Confederation of Finnish Industries EK, 2009; Vironmäki & Jokinen, 2009). Structures of co-operation can contain multiple things like project planning, methods for problem solving and administrative, the terms of contract, offering, outcomes and information exchange. Clear structures, rules and methods create mutual trust and decrease uncertainty, because trust relies on strong bonds of mutual understanding and adjustment (Bruneel et al., 2010; Chakrabarti & Santoro, 2004).

The content of doing is the name of the game; then the results and outcomes are serving all participants. All firms cannot be pleased, so it is better to concentrate on specific competence areas and interests (Johnston & Clark 2008; Parantainen, 2007). The interests and needs of industrial firms must take into account in the planning of research objects and themes. Firms usually seek deeper information for their business whereas universities are trying to get current data and information from industry. Finding and mapping out of the content and interests demands active two-way information flow and discussion. In addition, academic researchers have also seen the major and classical problem in the differences in orientations. University research is often very theoretical and it is perceived long-lasting (1-5 years) while firms are usually concentrated on short-term research, because their needs are mostly pragmatic

(Bonaccorsi & Piccaluga, 1994; Confederation of Finnish Industries EK, 2009; HSE yrityspalvelut, 2009; Meyer-Krahmer & Schoch, 1998).

All the challenges of U-I co-operation are not common. That is why those cannot be solved together, but those need to be taken care of by native organization. Challenges in industrial firms are quite simple in comparison with challenges in universities. The problems are usually financial and are connected with the economic situation of firms. The complexity is the reason why problems in universities could have a bigger affection for the implementation of U-I co-operation. Table 2 represents the challenges of U-I co-operation and separates them to their origin.

Table 2: The challenges of U-I co-operation.

<table>
<tr><th colspan="2">Challenges are originated from…</th></tr>
<tr><td>…university:</td><td rowspan="2">…university and industry:</td></tr>
<tr><td>People with good personal connections fears that systematic U-I co-operation jeopardize their personal connections or they have to share (resistance of change).</td></tr>
<tr><td>Unclear and undefined service portfolio and - offering.
Slow and undefined internal processes and procedures of universities.
How take the size and needs of different firms into account.
Long-term orientation (>1y)</td><td rowspan="3">The missing of mutual content and structures</td></tr>
<tr><td>…industry</td></tr>
<tr><td>Rapid changes of organizational structure (disappearance of the key players).
Perpetual hurry and lack of resources.
Rapidly changing needs.
Short-term orientation (<1y)</td></tr>
</table>

Personal connections act a crucial role, because many co-operations come through those persons. In literature, those kinds of people are called champions and their role is crucial especially when co-operation is initiated (Mead et al., 1999; Santoro & Chakrabarti, 2001). Good personal relationships should take care of, but at the same time, those should support mutual benefits and the significance of those should not be crucial. Instead of protecting the contacts too tightly, attitudes should change. The organization and co-operation would work more effectively if information and contacts are more widely available.

PRODUCTIZATION OF SERVICES

Productization of services is differing from product productization. A product is something which is manufactured in production, while service is something, which someone is offering to someone. It is intangible and does not result in the ownership of anything (Kotler, 1997). People haven't got used to call services as a product and the selling of expertise is not seen as a selling of products (Sipilä, 1995). However, if services are wanted to sell and offer effectively, those need to be made more product-like.

Productized services

The productization, or service concept, is an essential element in defining of offering and it starts from the deep understanding about services and customers. It demands

analyzing the needs of the customers, designing the service and developing the ability to produce in order that mutual objectives are met (Johnston & Clark, 2008; Sipilä, 1995). Therefore productization is a key factor that demonstrates the potential value, quality and benefits of the service for customers (Johnston & Clark, 2008; Saaksvuori & Immonen, 2008).

Sipilä (1995) has recognized four different levels for productizing. On the first level, internal productization, organisations try to make sure that planning and development is executed well at the first time and after that there is no need to do it again (Lehtinen & Niinimäki, 2005). Internal productization is a natural phase, if services are wanted to produce as effectively and well as possible. In addition, standardized and defined internal processes make possible to repeat service multiple times as defined (Saaksvuori & Immonen, 2008).

Second level is the developing of supporting processes. Organization develops such methods or information systems that enhance the effectiveness of customer cares and situations. On the third level service is fully productized and the property rights or licence can be resold. Services are also defined and forming clear entities, which could be offered to customers as such or modified (Saaksvuori & Immonen, 2008; Sipilä, 1995). The total chain of processes must be able to handle and described if services are wanted to produce and provide effectively (Johnston & Clark, 2008).

The fourth and the last level is repeatability, which means that service is packaged in specific form to be delivered via distribution network and so on. All those phases and levels are not necessary as long as the quality and effectiveness of the processes can be ensured, but this depends on organization's strategy, customers and competition situation (Saaksvuori & Immonen, 2008; Sipilä, 1995).

Productization can describe the nature of services provided by the whole organisation, or just an individual service as a part of a service portfolio (Johnston & Clark, 2008). However, well-structured and productized service portfolio and concepts can be seen as a potential driver of agility. Portfolio strategies are often created concurrently with other organizational capabilities making most services architectures idiosyncratic and extremely difficult to imitate (Voss & Hsuan, 2009).

How to create a well productized service

Service production and delivery have become more productive and responding to fierce competition is demanding ever better services. In addition to the growing need of services, the need to customize service for the individual customer remains (Saaksvuori & Immonen, 2008). The mere idea about good service is not enough, but it must be concretized into customers' mind. That is the issue to which productization helps (Johnston & Clark, 2008; Parantainen, 2007). Parantainen has listed six common and typical milestones to create well productized services. Milestones help service providers to check out, which phases they have achieved and where they still need to improve. In some extent, milestones supplement levels that Sipilä (1995) has introduced. According to Parantainen the milestones are following:

1. Some procedures are starting to stand out. It means that service providers start to use or copy such procedures, which have worked well in the past,
2. service gets a name and it takes a shape. Smaller and simpler services can have even a price, but usually it still depends on the case,
3. the content becomes stable, which makes the solidifying of the price possible,
4. this phase is the first one, which consists of real signs of productization; services start to multiply inside of the company, from person to person,
5. services start to multiply outside the company. This is the first step what is done in purpose, while first previous steps can be unintended. At this moment, steps and phases of services must be well documented; only by it, repeating of service is possible outside of the company – with or without developers. Usually in this phase, service is divided into modules to help the customization and
6. the sixth phase can be compared with Sipilä's (1995) fourth level, because in this phase, services are ready for resold and delivered via distribution network.

Productization serves multiple means to improve value creation and make it easier; for example, by it comes also the standardization and scalability. Without productization and standardization, it is possible to over engineering the processes; this usually decreases the effectiveness (Saaksvuori & Immonen, 2008; Simula et al., 2008). Scalability comes by the customization, which helps to fit services for every customer and helps to manage supply chain better (Hsuan, 1999).

Productization is not just putting services in well-defined packages; it is the set of interrelated tasks that together create a service. At the same time, it is a continuous improvement process for both universities and firms. The purpose of the productization is to provide a clear picture about the offering of organization and what the customer receives. Productization specifies services and guarantees the shared understanding about provided and received value of the services. It has found out that good service reduces conflicts and increase customer loyalty. Such customers are less likely to change a service provider.

Johnston and Clark (2008) have demonstrated: "At an elemental level a university provides lectures, food, accommodation and books, but what its customers are looking to acquire is something much greater an 'educational experience'. Through productization and service concepts, universities make their offering much more desirable and holistic. Basically, productization is a mechanism that links operation, processes and marketing together (Johnston & Clark, 2008).

INDUSTRY CO-OPERATION AT THE UNIVERSITY OF OULU

Emphasizing of the third mission of universities and changed economic structure has forced universities to reconsider the positioning of industry co-operation. At the moment, co-operation between the University of Oulu and industry is good and fruitful too, but it is casual and mainly bonded to a few people. The issues faced by firms are often impossible to simulate in laboratories and as a consequence research in technological and applied fields, like the Industrial Engineering and Management (IEM)

require contact with industry. In order for universities to influence society (D'Este & Patel, 2007; Vironmäki & Jokinen, 2009) and to achieve the objectives of teaching and research, industry co-operation is a very important role.

Case study

The research data was decided to be collected from interviews. The aim of this study was to study the need and possibilities for productization in the context of U-I co-operation. That is why interviews were decided to be conducted in the DIEM at University of Oulu, and one case company, which can be considered as one of the main partners. The case company is one of today's most highly valued electronics and high-technology brands in the world. The company has stated that the strength of the Finnish innovation system comes from the wide-scale co-operation between universities and industry in Finland. The potential of universities and institutions should be utilized better and the number of creative co-operations could be increased.

In this research, a case study strategy was decided to use. A case study is an empirical research tool that studies a phenomenon within its real-life context. When research is in the early stage and the boundaries between the phenomenon and its context are not clearly evident, case study is appropriate and can provide new insights. Evidences can be collected from multiple sources (Ahola et al., 2008; Eisenhardt, 1989; Yin, 1989). As earlier stated, there is not much of research or data on the subjects of co-operation frameworks and how those are organized.

Thirteen interviews were carried out: three for university representatives, three in DIEM and seven in the case company. Every firm representative was experienced and high-ranking. University and DIEM representatives differed from researcher to professor, but every one of them have lots of experiences about U-I co-operation. Interviews were made for one person at a time, except one interview where two people were present. The amount of interviews was not limited in any way, but the purpose was to get enough data that answer and propositions start to accumulate. Because natural discussion and flexibility were seen very important for this research and interviewees, the questions were quite broad and the interviews were held quite loosely defined. For the purpose of credible and reliable research, all interviews were recorded and transcribed. The interviews concentrated on the following topics: the present situation, experiences, organizing, benefits and the development of U-I co-operation. The main focus was still in the development of co-operation through the productized services of universities and how productization was seen fit for U-I co-operation.

Results

In general, U-I co-operation was seen important for every participant and even for the development of local area. Experiences have been good and the personnel of firm and university were willing to continue it. Interviewees also believed that co-operation have had a positive impact on competitiveness, but especially in long-term it has been very difficult to measure or proof. Traditionally, co-operations have been concentrated on different kind of thesis and short- and long-term research projects.

Instead of benefits that have appeared, U-I co-operation seems to be in “a depression” at the moment. Co-operation has been carried out a lot and in many ways, but all potential has not exploited and it has not served the needs of the participants as well as possible. The problems are mainly related to the challenges that have been already been recognized in this paper:

- No clear content and objectives for co-operation,
- co-operation bounded in personal contacts and interests,
- the common and mutual structures are missing and
- co-operation should be wide-scale and more synergistic.

Many firm representatives said that U-I co-operation is fully bonded to personal interests and connections. That could be one reason why there were not any signs of tight objectives for co-operations. Only some qualitative objectives were stated, for example, that co-operation should be carried out only with top-research or top–universities. However, many interviewees, mostly from university, said that there should be some goals and objectives to ensure the effectiveness, success and organizing of relationships and co-operations.

It was made pretty clear that information must be spread more effectively between university and a firm in order that mutual content can be found. If co-operation is wanted to last and to be valuable, there must be some content and meaning on co-operation. Content can not be created from a scratch, but it must be related to partners’ competencies and interests.

Compared with normal service providers, many of the universities have not brought out and advertised their expertise and offering. One of the university representatives mentioned: “Profiling of our skills and competencies is crucial if our know-how is wanted to promote for co-operators”. If universities want to act as a service provider and co-operation is wanted to develop, there must be something concrete that can be presented for firms.

According to interviews it seems to be clear that universities should productize their services and create a service portfolio. If long-term industry co-operation is wanted to be more systematic and appropriate, information should be spread more actively and universities or departments should be able to present their service offering and portfolio clearly. Productization of expert services is absolutely a solution for that; a clear “service menu” could solve and clarify many problems.

Productization of a course assignment

It has been shown that U-I co-operation has essential benefits for both industrial firms and universities, but it suffers from the lack of structures and awareness of services as well as from the common challenges that U-I co-operation has usually faced. Thus, it is justified that the productization of services is one possible way to unify and systematize

the offering of universities. This would enhance U-I co-operation and concretize the offering for customers and help finding the mutual content and structures.

Based on findings of this research, one of the DIEM's course assignments was decided to be productized to overcome challenges related to industry-university co-operation. The need for such productization was well justified: multiple student groups were carrying out the same task in different firms. Basically the brochure about the assignment was created in order that every single firm would get a clear conception about the requirements. In table 3 elements of productized university services are shown and also one example is given. Elements are very much familiar with the literature, but in the case of university services, the value for students and university must be emphasized, because the objectives of services may be educative – for example in small assignments.

Table 3: Elements of productized university service.

Element	Description	Empirical example: course assignment
Name		
	Service must have a name, so that it could be recognized.	**A course assignment about project business**
Person in charge		
	Good results and quality demands some person in charge.	**Professor X**
Availability of service		
	When services is available and executed.	**Spring 2011**
Description and implementation		
	Service description and how is it executed	**The assignment will be executed in a group of 4-6 people and it will contain both theoretical and empirical part, which is carried out by the interviews of firm personnel. The results will be presented in the final seminar.**
The content and objectives of service		
	Clearly defined content concretizes service in customers' minds while objectives describe the purpose of service.	**The themes of an assignment: the special features of a project business, business models of a project based firm, sales and marketing of projects. The objective is to solve some problem related to firm's business and generate the improvement suggestions.**
Value creation for industry / customer		
	What can be achieved through the service.	**A solution for a specific problem; the enhancement of an employer image; straight contact with students.**
Value creation for university		
	Why service producing and offering is important for students and university.	**Students will get acquainted with real business problems and phenomena and have a chance to analyze the influence of those. In addition, students are getting familiarized with real problems and practices. Solving and applying of**

		those is necessary for the development of expertise.
Resources		
	The number of resources that are needed from the firm and resources provided by university.	**University provides 4-6 highly motivated students to carry out the assignment. Required resources from firms: Involving in choosing the topic/problem; 1-3 people for being interviewed; giving feedback.**
Price		
	The price is usually the first thing which is asked for. Because of customization, fixed price is not necessary, but service must have some sort of indicative price, what can be told for a customer.	**Free.**
Results		
	All results and outcomes are always confidential.	**The best assignments and results can be published, but firm has a right to forbid it.**

DISCUSSION

According to both current literature and empirical findings, U-I co-operation was seen very important from both industry and university perspective. These challenges are often related to lack of systematic way to provide services and make the offering visible for both parties in service production. Productized services are one possible way to maximise value and objective achieving (Simula et al., 2008). Value of productized services is much easier to measure and identify with productization, because services are clearly defined and the content is well-known. Table 4 discusses about the challenges that can be solved through productization.

Table 4: The challenges that can be solved through productization.

Challenge:
• **Solution through productization?**
Long-term orientation (1-5y) vs. short-term orientation (3mm-1y)
• **Defined services help to determine the content and objectives.** • **Suitable services and forms can be easily found.** • **Different types of orientations and requirements can be taken into account.**
Theoretical approach vs. pragmatic approach (long-term vs. short-term)
• **The theoretical approach is a standard part of any university's research procedures. Such things are defined and explained in the service description.** • **Services can be modified to match the needs of the customer with customization.**
Bonded to some person & variable organization structure
• **Services are clear entities that are available and accessible to all people.** • **Personal connections and variable organization structures won't be restrictive things anymore.**
No clear contact channels and content
• **Productized services and concepts are concrete and easily exploitable.** • **Productized service contains plenty of details, such as contact information.**

Productization is a continuous process, which aims to cost efficiency and customer orientation. Harshly, productization can be divided into two steps: inbound and

outbound productization. Before services are being offered and value can be produced, internal processes must also be productized. After that, effective value producing and service offering, outbound productization is possible (Simula et al., 2008). With those two steps, universities are able to implement productization as a part of their key processes (Valminen & Toivonen, 2007) and the most of the challenges in U-I co-operation can be solved or at least be reduced. Although the benefits of productization are undisputable, it is surprising how few organisations have clearly defined service concepts (Johnston & Clark, 2008). Thus, it can be argued that with productization universities can define their service portfolio and concepts more systemically and enhance their role as a service provider.

The benefits of productization based on well-defined procedures and services packages, which leads to the following things:

- Better quality and management of services leads to more stable, effective and manageable processes,
- the communication with customers is much easier and customer perspective can be taken more deeply into account and
- services are partially standardized and partially customized; standard parts ensure flexible and efficient processes while customization ensures the fulfilment of customer requirements.

Those inevitably lead to the better competitiveness and more valuable results. Usually, a good service reduces conflicts and increase customer loyalty. In addition, such customers are less likely to change a service provider (Johnston & Clark, 2008).

Sadly, the U-I co-operation has been bounded to personal contacts and in some extent it has had a negative impact on the number of co-operations. Personal contacts are important, but those may not be limiting factors. Productization enables that processes for co-operation will be standardized and stated. Naturally, this means that more people can benefit from the co-operation and it would be less dependent on the competence of individual experts.

Productization makes the implementation of co-operation easier and enhances the significance of co-operation. Because universities have already recognized the importance of U-I co-operation, the most important thing is to emphasize universities as considerable partners. When universities or departments clearly present their service portfolio and use it as “a menu”, any firm – especially new applicants – could be aware of service offering. We can presume that when the gaps and risks are minor, it encourages firms to start or increase the amount of co-operations. By that, universities would be more capable of serving firms and people in their region and act as a social influencer, which is also the third mission of universities. It could be assumed that the more partners’ universities have the more they will get funding.

In spite of benefits, productization is not the key for the opening of co-operation, because effective co-operation demands that offerings and needs meet each other. The implementing and opening of the co-operation demands active and two-way

communication. In that phase, productization has the biggest influence. It concretizes the offering, help fulfilling needs and finding the content and structures. In addition, clear structures, rules and methods create mutual trust and decrease uncertainty, because parties see the relationship itself valuable and are more willing to establish. Such things could have major and positive affection for the U-I co-operation and sustainability of it.

Managerial implications

The major managerial implication of this research is that universities should pay more attention to the productizing of their expertise and services. At this moment, it appears that industrial firms are not aware of offering and services that the universities could offer (Confederation of Finnish Industries EK, 2009). Productization would develop universities internal processes and procedures, which have a direct impact on the quality and effectiveness of working. Productization also set clear requirements for industry: how to purchase services and what kind of resources are required from them in service production. This emphasizes that service production is always co-operation between the supplier and the customer.

Productization also helps to take the variable needs of industrial firms into account and make sure that the results meet the requirements better. In addition, the improvements of productivity are one way to measure the effectiveness of the productization. At the same time, by more systematic co-operation, the personal relationships and changes of organizational structure are not as a big role as those are now. Because of the decreased workload, the better quality and productivity of co-operation, it can be argued that after the productization firms would have more time and will for U-I co-operation.

With true productization, the needs and objectives of industrial firms could be fulfilled better. However, firms should remember that the main mission of universities is to do research and new science instead of subcontracted work for industry. That is why universities' approach is usually perceived very theoretical and research areas can be completely new, hence satisfied results cannot always be guaranteed. The risks of conflicts can be decreased with a good preplanning and an effective two-way communication.

CONCLUSIONS

In this paper, the main focus has been to examine is the productization of university services as a way to enhance and develop U-I co-operation. Based on our research findings, university offering should be clearer and better defined; thus the missing structures and content could be easier to find. The lack of clear understanding what university can provide for industry leads to perceptions that university research and co-operation too theoretical for them (Confederation of Finnish Industries EK, 2009).

Productization is not a solution for all the challenges in industry-university co-operation. Many of those can be solved inside the university or the department, but we still need to map out the needs of the firms and the common content for co-operation. In the

interviews active information sharing was suggested being a solution for the discussion about needs and offerings. Probably, the only way to success, is the continuous communication between universities and firms, where the productized service portfolio act as an element supporting the objectives and interaction. That kind of arrangement could work quite well, because it would be easier respond to customers' requirements and achieve the objectives of own. These create a basis for the long-lasting and mutually beneficial co-operation.

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PROBLEM-BASED LEARNING IN UNIVERSITY EDUCATION: DO PSYCHOLOGICAL PREFERENCES MAKE A DIFFERENCE?

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ABSTRACT

Problem-based learning method is widely used in different levels of education. In this article we examine what is the role of psychological traits in problem-based learning. In the measurement of personality we used a questionnaire based on the Myers Briggs Type Indicator (MBTI) framework. MBTI framework consists of four dichotomous types that differentiate between how individuals mix with others on a social basis (extroversion vs. introversion), how individuals search out information (practical vs. creative), how individuals make decisions (analytical vs. beliefs), and how individuals relate to the environment (structured vs. flexible). We have collected and analyzed data on psychological characteristics and learning performance measures of 179 master level university students who participated in one of the three Project Management-courses provided in the University of Southern Denmark (SDU) between 2009 and 2011. In all of the three courses problem-based learning approach was used as the principal pedagogical method. Results show that females perform better than males, but when analyzing psychological characteristics statistically significant differences were not found. Still it can be said that structured students had somewhat better grades than the flexible ones. The implications are discussed.

Keywords: problem-based learning, psychological preferences, project management

INTRODUCTION

Problem-based learning (PBL) is widely applied learning method. It has been used in higher education for over forty years as a method of teaching the practical application of knowledge in a real-world setting. It originated first at Cleveland, Ohio (Case Western Reserve University) in the 1950s but one of the Canadian medical schools, McMaster University (Hamilton, Ontario), is more commonly mentioned as the origin of PBL. First references to PBL in McMaster University can be found from 1969, but by the 1990's it had been adopted to other North American, European, and Australian schools of medicine, engineering, architecture, business and management, and law (Barrows, 2000; Boud and Feletti, 1997; Hansen, 2006; Hmelo-Silver, 2004; Prince and Felder, 2006; Smith, 2005; Torp and Sage, 2002). The method is widely applied in management education, and business

schools can be actually seen playing a leading role in developing the method (Gilbert and Foster, 1997).

There is growing body of research focusing both outcomes and challenges related to problem-based learning method (see e.g. Bigelow, 2004; Boud and Feletti, 1997; Hansen, 2006; Hmelo-Silver, 2004; Kloppenborg and Baucus, 2004). However, research has not addressed how suitable PBL as a learning approach is for different types of students. According to type theories people can be categorized into discrete personality types (Eysenck, 1991). The psychological preferences can be determined by using Myers Briggs Type Indicator (MBTI), which is a psychometric self-report method widely used to measure psychological preferences to relate to world and process information (Myers and McCaulley, 1985). The basis for this method is derived from the 1920's typological theory by C.G. Jung (1971).

Existing research on learning and personality types in other context suggest that student apply different learning strategies and thus psychological preferences may affect learning outcome (see e.g. Opstad and Fallan, 2010; Taherr et al., 2011; Tyagi, 2008). We continue this line of research by analyzing the influence of students´ psychological differences on learning-performance in the context of problem-based learning. We aim to answer the following research question: "What is the role of psychological preferences in problem-based learning?"

In order to answer to the research question we have collected and analyzed data on psychological characteristics and learning performance measures of 179 master level university students who participated in one of the three Project Management-courses provided in Denmark between 2009 and 2011. In all of the three courses problem-based learning approach was used as the principal pedagogical method.

The structure of the paper is following: First we review some basic facts from the theory of problem-based learning and psychological preferences. Then the methods and data is introduced, and in the empirical part we discuss how psychological characteristics impact on learning performance when using PBL as learning method. Finally in the discussion part the implications are discussed and conclusions are drawn.

PROBLEM-BASED LEARNING IN PROJECT MANAGEMENT EDUCATION

PBL has been defined as "the learning that results from the process of working towards the understanding or resolution of a problem" (Barrows and Tamblyn, 1985). Problem-based learning method activates and challenges students to solve complex, real world problems independently by identifying the problem, acquiring the needed information for solving it and reproducing knowledge as teamwork while teaching personnel only supports the learning process as being a resource available. Teaching personel can for example establish criteria for acceptable task quality and team performance, provide advice, and encourage and recognize specific accomplishments (Peterson, 2004). Therefore PBL is based on a fundamentally different learning process than traditional classroom teaching in which instructor transfers his/her knowledge to students.

When using PBL method the problems are ill-structured (Boud and Feletti, 1997, Peterson 2004). At first, the problem is presented to the students by a faculty member. In some cases, the problem may be so fuzzy and complex that additional questions and discussions are required in order to even identify the problem. In the next step, the students identify the facts that are provided in the problem, analyze it, and seek for information to solve the problem. Several possible solutions can be generated and iterated until the best solution is decided. (Hansen, 2006; Hmelo-Silver, 2004; Milne and McConnell, 2001). Finally the solutions of the student groups can be discussed together to see and compare different kinds of outcomes. (see Figure 1)

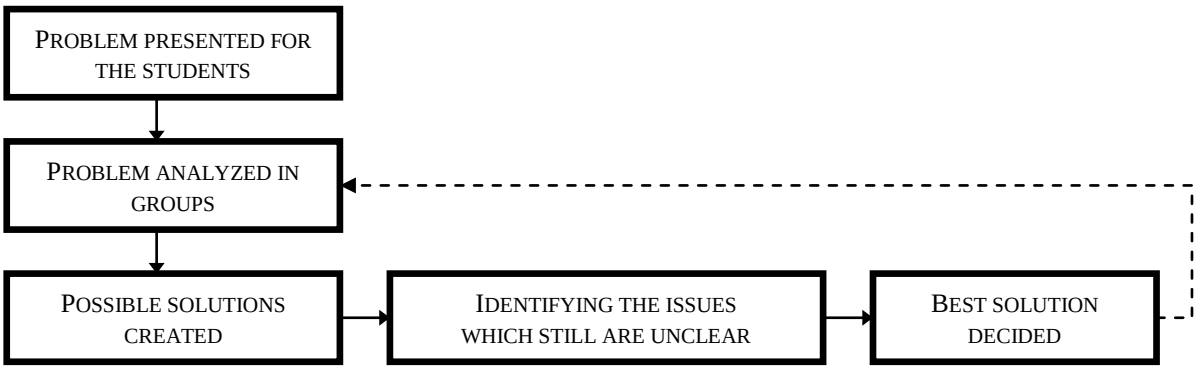

Figure 1: Problem-based learning process.

There are many variations of PBL process (see e.g. Bigelow, 2004; Boud and Feletti, 1997), but in the end the PBL core process is quite simple (Hansen, 2006; Hmelo-Silver, 2004). PBL method has also been applied in different kinds of situations. It is used in specific learning events within a course as well as a system level application in which a whole curriculum is based on PBL; and of course individual course level too (Kloppenborg and Baucus, 2004).

Furthermore, PBL is based on the assumption that students learn best in teams. Learning is cooperative and self-directed (Kloppenborg and Baucus, 2004; Hansen, 2006), and problem solving as team work, especially in case of a challenging problem, requires all team members to participate in discussions, engage in information sharing and be involved in research of literature or other sources (e.g. interviews of practitioners or discussion with faculty members). The students need to take an active role in the learning process, and it can be quite frustrating for students, as they face a lot of uncertainty in the process (Peterson, 2004). However, if successful, through this kind of process students gain deeper understanding of the subject and afterwards, will remember what they learned (Bridges and Hallinger, 1997; Woodward, 1997).

When talking about life-long learning, PBL is one of the most effective learning methods (see e.g. Albanese and Mitchell, 1993; Dolmans and Schmidt, 1996; Smits and Veerbeck, 2002). Benefits of PBL method has been widely studied (e.g. Dolmans and Schmidt, 1996; Woodward, 1997; Bridges and Hallinger, 1997; Blumberg, 2000; and Duch et al., 2001) and for example Smith (2005) has summarized the benefits into nine aspects: 1) Problem solving skills, 2) Knowledge retention and recall, 3) Understanding of material, 4) Thoughtfulness, 5) Focus on practice-relevant knowledge, 6) Knowledge integration, 7) Teamwork, leadership,

and social skills, 8) Life-long learning skills, and 9) Motivates student learning. For further details see Appendix A where Kujala et al. (2010) have introduced ways to achieve the benefits of PBL in the advanced course in project business.

The suitability of PBL as learning method in engineering education has been widely studied (see e.g. Hadgraft, 1997; Johnson, 1999; Mills and Treagust, 2003; Perrenet et al., 2000; Woods et al., 1997). Williams and Williams (1994, p. 361) have been summarizing the similarities between PBL learning method and the teaching design in engineering programs:

- Both have a large number of phases or stages through which to pass during the project or problem.
- Both start with an identified problem or situation which directs the students' area or context of study.
- Student initiated research is relied upon for the student to progress through the project as well as for their own learning.
- Both require high levels of student initiative, students need to develop motivation and organization skills.
- Both lend themselves to long-term projects, PBL may be used over a short time frame but this does not detract from its ability to be used effectively over a longer time frame, as is usually associated with technology projects.
- Both are open ended with regard to outcomes, allowing the student the opportunity to choose, after appropriate research an outcome that interests them.
- Observational skills are identified as having a high priority, especially in the initial stages during identification of the problem.
- Student reflection is an important aspect of both models, the student is encouraged to evaluate fully the outcome they have achieved.
- Both rely upon group work.

Problem-based learning method is related to other pedagogical learning approaches, for example work-based learning, and especially with project-based learning (Helle et al., 2006). In both methods students face complex real world problems without clear definitions or only one correct answer, and teaching personnel have a supportive role in the problem solving process (Thomas, 2000; Milentijevic et al., 2008). However, PBL focuses on understanding the phenomena behind the problem and solving the problem itself is subsidiary. In project-based learning the aim is to carry out an output, for example report or thesis, and the problem needs to be solved. (Helle et al., 2006).

All in all PBL is widely used, versatile method which can be used in different levels of education. Still it has not actually been studied how it fits to different people. In the following section, theory of psychological preferences, we describe, how people can be classified into different groups, and finally we combine these two theory aspects in our research.

PSYCHOLOGICAL PREFERENCES

Psychological preferences have been used in prior studies to explain learning of individuals. Initially Jung classified people only into extraverts and introverts but later on added the distinctions between sensing vs. intuition (practical vs. creative) and thinking vs. feeling (analytical vs. beliefs). Myers and Briggs further extended the descriptive theory with the addition of judging vs. perceiving (structured vs. flexible). MBTI framework (Myers and McCaulley, 1985), which is a dynamic framework, consists of these four dichotomous types. The framework goes further into type dynamics, thus not only focusing on where an individual stands each opposite type descriptions but looking into the implications behind 16 possible preference-combinations. The use of MBTI as a meaningful measurement tool for psychological preferences requires the consideration for the dynamics between all four pairs of preferences. However, when it comes to research, these strict requirements have often been overlooked and the pairs of preferences have been investigated separately. The research questions have often not been tied to the dynamics of MBTI. This is also true for the studies on psychological preferences and learning.

The studies on psychological preferences in MBTI and preferred learning style show some differences. Extroverted students rather collaborate with others and seek advice on how to proceed than work alone (Elliott and Sapp, 1988). They favour learning environments that provide active participation and experimentation (Gordon; Coscarelli and Sears, 1986; Hinkle, 1986; Luh, 1991; Penn, 1992). On the other hand, introverted students like to observe and reflect upon their observations in a more private manner (Hinkle, 1986) and thus adapt more easily to traditional lecture environments (Fourqurean et al., 1990).

Practical types seem to prefer rather systematic and process-like approach to learning and they like to know and master the existing facts (Drummond and Stoddard, 1992; Beyler and Schmeck, 1992), whilst creative types are more innovative (Jacobson, 1993) and holistic learners (Beyler and Schmeck, 1992). According to type theory practical learners can create new ideas and be creative but usually only after first carefully reviewing all the existing knowledge. Conversely creative types get inspiration from brainstorming without any limits and then later they search for the missing facts.

Those making decisions analytically have a systematic approach to learning, whilst those making decisions more based on beliefs prefer holistic learning (Gordon et al., 1986; Beyler and Schmeck, 1992). Analytical types like to learn independently and appreciate assignments that are logically understandable. For the belief-based types supportive learning environment is of special importance.

Those with structured approach to environment have been found to prefer systematic learning settings with clear structure and independency that allow them to plan ahead (Fourqurean et al., 1990; Drummond and Stoddard, 1992; Beyler and Schmeck, 1992). Alternatively, those with more flexible approach to environment like unstructured and more unpredictable teaching methods that do not set constraints to study methods (Drummond and Stoddard, 1992). Flexible learners are also more collaborative (Elliot and Sapp, 1988) and holistic (Beyler and Schmeck, 1992).

Psychological preferences in relation to how an individual would like to learn new things gives us important information on what motivates certain kinds of students. However, it does not tell us about how these students actually perform. The link between dichotomous MBTI types and actual learning has been studied by looking at performance on standardized aptitude tests, such as IQ test and Scholastic Aptitude Test (SAT), but also by looking at real classroom performance and achieved grades. Analytical types seem to exceed in mathematical parts of SAT (Gallagher, 1988), which can be easily understood through their analytical style. Flexible types seem to exceed the structured types in aptitude tests, whilst the more structure-seeking types rank better on real achievements (Myers and McCaulley, 2009).

Considering the broader picture, introverts and creative types show consistently superior performance (e.g. Myers and McCaulley, 1985; Kalsbeek, 1987). Their superiority is particularly apparent in verbal and abstract tasks (e.g. Schurr and Ruble, 1986; Schurr et al., 1988). A part of the explanation for the better performance of the intuitive types could be that they trust their intuition more and form quick overall impressions as opposed to practical types who need to double-check and work through questions more slowly. Standardized tests and exams are often time-limited. Another noteworthy point is that, exams have traditionally required silent and independent working through the exam. This type of an environment is more readily suitable for introverts than extraverts.

Interestingly, Schurr and Ruble (1988) found that academic achievement in more practical and applied courses was actually better in extraverts and practical types. In their study introverts and creative learners obtained higher scores only in more abstract and theoretical courses. Thus, one could argue that there could be interaction between personality preferences and different kinds of learning environments and teaching approaches.

METHODS AND DATA

Participants and procedure

The data for this study is drawn from three master level project management courses conducted in University of Southern Denmark (SDU) between 2009 and 2010. Each of the courses applied problem-based learning method in teaching. Two of the courses were 7,5 ETC in size and one 10 ETC. In each course lectures were given mainly by same lecturer and during each lecture students were given theoretical introduction that was followed 1 to 2 ill-defined problems that students were asked to solve in groups of 3 to 4 persons. Student´s solution to the given problems were discussed and reflected at the end of the lecture. The course structure for each of three courses is attached in Appendix B. In two of the courses (course 1 and 2) the length of the lecture was 90 minutes and in one course (course 3) 135 minutes. The full list of lectures by course is attached in Appendix B.

The final sample of the study consists of 179 students. The students represented wide range of different study programs including; economics, business administration, public health, tourism, and environmental management. From the students 37.6% were male and 62.4% female.

Learning performance evaluations

The learning performance was measured through course grade. Assessment of the course grade was based on the results of 72 hours take home group assignment and individual oral examination. The take home assignment was done at the end of the course in a group of 3 to 4 students. In each course, the assignment consisted of project proposal that students were supposed to prepare based on the given data present for fictive decision-makers. For each student groups, students were asked to divide the results into number of parts that corresponds the number of members in the group. The take-home assignment was followed by 20 minutes individual oral examination. The oral examination included two parts. During the first part student were given 10 minutes to present the results of the group work. The part of the group work to be presented by each student in a group as well as the order of examinations was not known before by students. During the second part of the examination that followed the presentation, each student were asked questions to test their theoretical understanding of the topics covered in the course as well as their ability to understand and apply the concepts in the given case.

The students were evaluated using Danish 7-point scale. In the Danish seven point scale grade 12 refers to "*an excellent performance displaying a high level of command of all aspects of the relevant material, with no or only a few minor weaknesses*". Grade 10 is given for "*a very good performance displaying a high level of command of the most aspects of the relevant material, with only minor weaknesses*". Grade 7 correspond "*a good performance displaying good command of the relevant material, but also some weaknesses*". For the grade 4, student is expected to show "*a fair performance displaying good command of the relevant material, but also some major weaknesses*". Grade 2 refers to "*a performance meeting only the minimum requirements for acceptance*". Grade 0 is given for a student who shows "*a performance which does not meet the minimum requirements for acceptance*". Finally, grade -3 refers to "*a performance which is unacceptable in all respects*".

Two assessors evaluated the learning performance of each student in an oral exam. The exam grade consists of assessment of both written case report and oral examination of the understanding related to the course area. Each student was evaluated separately. In each assessment two evaluators gave grade for the student separately and in case of grades given by assessors were different the final grade consists of average of two grades round up to next full grade. The average grade for the sample was 8.1 with a standard deviation of 2.9. The distribution of grades is summarized in Table 1.

Table 1: Distribution of grades.

Grade	**-3**	**0**	**2**	**4**	**7**	**10**	**12**
Count	**0**	**1**	**5**	**32**	**55**	**52**	**34**
%	**0**	**0.6**	**2.8**	**17.9**	**30.7**	**29.1**	**19.0**

Questionnaire on psychological preferences

The measurement of personal traits was developed based on the 4 personal dimensions proposed by Myers and Briggs (1995). The data on personal traits for each student was collected during the course in one of the lectures. The assessment of personal traits was

facilitated by lecturer that was responsible for the lecture. We assessed the personal traits of students dimension by dimension by asking them to compare one by one pair of adjectives related to a specific trait, e.g. “gets energy from other people” vs. ”gets energy from own ideas”, and to decide which of the two adjectives would describe them better. After comparing set of adjective pairs related to a specific dimension, e.g.” relations to others”, students were asked to calculate the number of adjectives that matched two both two trait, e.g. “extroversion” and “introversion”, and report, which of the two traits had more adjectives that would match their own personality. The full list of adjectives that was used in evaluating personal traits is attached in Appendix C. Descriptive statistics related to four personal traits are summarized in Table 2.

Table 2: Distribution of personal traits.

	Relation to others		**Information gathering**		**Decision-making**		**Lifestyle**	
	Extrovert	**Introvert**	**Practical**	**Creative**	**Analytical**	**Beliefs**	**Structured**	**Flexible**
Count	**104**	**75**	**107**	**77**	**101**	**78**	**91**	**88**
%	**58.1**	**41.9**	**57.0**	**43.0**	**56.4**	**43.6**	**50.8**	**49.2**

Data Analyses

The relationship between four personal traits and learning performance was analyzed using T-tests. In the analyses we focused on the main effects. Thus, the interaction between the traits was not assessed but rather the effect of each preference was looked at individually. In addition, we controlled for the effects of gender on learning performance as prior research has shown that females get on average better grades (see e.g. Dayioğlu and Türüt-Aşik, 2007; and Sheard, 2009).

RESULTS

The means, standard deviations and T-test statistics of learning performance related to personal traits are depicted in Table 3. The mean values indicate that the learning performance of students with introvert trait is slightly better than students with extrovert trait. The results of the T-test, however, indicate that the observed difference in mean values is not significant. From the information gathering perspective practical students had on average better grades than those that are characterized by creative tendency. The differences between the two groups are not statistically significant. In similar vein analytical versus beliefs based decision-making did not show significant effect on learning performance, even though the analytical students received on average better grades than those with beliefs-based decision-making. The highest differences in learning performance were found when comparing students personal tendencies related to lifestyle. We found that structured students were granted on average with better grades than those with flexible lifestyle. The observed differences on learning performance are not statistically significant, but indicate clear trend.

Table 3: Means, Standard devistions and T-test statistics of learning performance by personal traits.

	Relation to others		Information gathering		Decision-making		Lifestyle	
	Extrovert	Introvert	Practical	Creative	Analytical	Beliefs	Structured	Flexible
Mean	8.0	8.2	8.2	7.9	8.2	7.9	8.4	7.7
SD	3.0	2.8	2.8	3.0	2.9	2.9	2.8	3.0
t	-0.46		0.67		0.62		1.64	
p	n.s.		n.s.		n.s.		< 0.1	

We also analyzed the effect of gender on learning performance. The average grade for female students was 7.2 (SD 3.1) and for male students 8.6 (SD 2.7). The observed difference is statistically significant ($t = -3.16$, $p<0.1$).

DISCUSSION AND CONCLUSION

Previous research has suggested that psychological traits have an impact on preferred learning styles and thus they may influence learning performance in different type of teaching settings (Beyler and Schmeck, 1992; Hogan, 2009; Taher et al., 2011; Threeton and Walter, 2009). In this research, our objective was to study the role of psychological traits in the context of problem-based learning. Our results suggest that problem-based learning is an effective learning method for individual with different type of psychological traits. Although structured students were granted on average with better grades than those with flexible lifestyle, it can be claimed that problem-based learning method supports varying learning styles.

PBL provides an applied setting for learning and for demonstrating skills and knowledge. The cases that portray real life business challenges imitate problems that people face in post-modern working life. These problems are not clear-cut or in isolation from the reality. Changing one part changes another part in a systematic way and this must be kept in mind when working on an assignment. The approach differs from the more traditional teaching environment whereby learning is more deductive and theoretical and where students can safely set limits between knowing the facts and knowing how to use the facts. PBL environment also assumes that students have social skills and motivation to collaborate and participate actively, just as is the assumption in modern-day working life. All in all, one could assume that practical extroverts have an advantage in PBL environment in the vein of the research by Schurr and Ruble (1988). However, based on our empirical findings practical extroverts did not show superior performance in the PBL environments.

On the other hand one could be equally surprised that creative introverts did not show their superiority in course grades as they tend to do generally better than practical extroverts (e.g. Myers and McCaulley, 1985; Kalsbeek, 1987). More traditional exams extend through the course of a few hours, whilst PBL approach is based on a longer period of time that allows for a more extensive information seeking and longer contemplation and experimentation time. Thus, the advantage that creative types might have in traditional exams by trusting their intuition and performing quicker in very constraint time-limits, could be out ruled in PBL assignment that extends over a weekend. Likewise, the traditional advantage of monitored silence for concentration and individually performed exams that

has been favoring introverts is not enabled in PBL approach. All in all, one could argue that PBL approach could attenuate the perhaps unequal advantage that being an introvert and being a creative type has given to students in the past years. However, this is pure speculation at this stage and yields for more research.

Our analysis imply that complex problem-solving in applied context benefits from a mix of different preferences, so that introverted, extroverted, analytical, belief-based, creative, practical, structured and flexible learning approach all are compatible with the problem-based learning process. Personal traits may also affect which type of roles, such as plants, resource investigator, coordinators, shapers, monitor evaluators, teamworkers, implementers, completer finishers and specialists (Belbin, 2011), students take in problem-solving teams. However, in this research we did not analyze how assignment of students with different psychological traits in problem-solving teams affects team performance and individual learning. Further research could identify whether problem-solving team composition is an important factor for explaining learning performance.

It also might be that statistically significant differences between psychological preferences and learning outcomes were not found because some other factors explain why some students learn better than others. Our findings show statistically significant difference between learning outcomes of male and female students, which should be further analyzed. Also, previous research has suggested that psychological preferences might not effect directly to learning performance but it might support different learning strategies. Individual students learn new things in different ways and it might affect on learning outcomes. PBL as a learning method provides opportunities to use different type of learning strategies and students may take different roles in problem-solving teams. Therefore we suggest that future research could explore what is the relationship between psychological preferences and learning strategies in problem-based learning environment.

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Appendix A: Ways to achieve the benefits of PBL in the advanced course in project business. (from Kujala et al., 2010)

Potential benefit of PBL (Smith, 2005)	**… and how to achieve these benefits in the context of an advanced project management education**
Problem solving skills	A student centered process that involves solving complex real world problems is an integral part of the course design.
Knowledge retention and recall	Students have limited practical experience and they will not be able to use acquired knowledge in their work. Students learn to recall and apply learned concepts and approaches when they face similar situations during the course (and hopefully in future work).
Understanding of material	Study material is used mainly in solving complex problems, which cannot be analyzed based only on "common sense", which leads to a more in-depth understanding of the relevance of the study material.
Thoughtfulness	Students have more responsibility for both creating relevant questions/problems and providing answers those questions, have increased thoughtfulness – a tendency to deliberate, question and be critically reflective of the course content.
Focus on practice-relevant knowledge	Discussion and problems that are presented during the course need to be up-to-date and well connected to practice either through faculty member interaction, visiting lectures from industry or student assignment to solve real world problems in companies.
Knowledge integration	In the course topics related to different disciplines are presented and students are encouraged to apply all available material to understand complex problems.
Teamwork, leadership, and social skills	Problems are solved in the groups and students have to take full responsibility for how their groups functions.
Life-long learning skills	Not all of the material that is required to solve problems are provided to the students, but they are required to gather relevant additional knowledge and material by themselves.
Motivates student learning	Problems solved during the course are practical and consist of complex problems that project-based firms are facing or have recently faced.

Appendix B: Course structures

Lecture	*Topics: Course 1 (7,5 ETC)[1]*	*Topics: Course 2 (10 ETC)[2]*	*Topics: Course 3 (7,5 ETC)[1]*
1	Introduction to the course, Project management in an organizational perspective	Introduction, The concept of projects PM history & development , Project mandate	Introduction to the course, Project management in an organizational perspective
2	The foundation of the project, Project mandate	Project mission and goals, Structuring of the project, Project process	Project process, Project mission and goals, Project mandate
3	Project planning, Structuring the project, Milestones	Milestone planning, Activity planning	Structuring the project, Milestone planning
4	Project stakeholders, stakeholder management, Project risk and uncertainty management	Project stakeholders, stakeholder management, Project risk and uncertainty analysis	Activity planning and critical path method
5	Detailed level planning, Organizing the project	Organizing the project, Staffing the project	Project stakeholders, stakeholder management
6	Project success	Project controlling, Project communication	Project risk and uncertainty management
7	Project controlling, Project communication	Consulting tasks, modes and roles	Organizing and staffing the project
8	Project team and team leadership, Teamwork competencies	Understanding of group processes, task- and maintenance processes and using different types of interventions as a consultant	Project controlling, Project communication
9	SimulTrain Exercise	Exercise	Project team and team leadership, Teamwork competencies
10	Programme management and porfolio management	Planning the project management training	Different types of projects and related managerial requirements
11	SimulTrain Exercise II	Evaluation of projects	Management of multiple projects
12	Overview of PM tools and issues	Teambuilding, Team leadership, PM behaviour	Overview of PM tools and issues
13	Exam preparation, Closing down the module	Different types of projects and related managerial requirements	Exam preparation, Closing down the module
14		PM models and project models	
15		Exam preparation	

[1] Lecture duration = 90 minutes

[2]Lecture duration = 135 minutes

Appendix C: Assessment of personal traits

ATTITUDE: RELATIONS TO OTHERS (9 items)	
Extroversion:	***Introversion:***
1. Gets energy from other people	1. Gets energy from own ideas
2. Needs relationships	2. Needs privacy
3. Active, talks a lot	3. Quiet, concentrated
4. Easy to get know	4. Hard to get know
5. Expresses feelings	5. Does not express feelings
6. Interested on many issues but at superficial level	6. Interested on few things but deeply
7. Many friends	7. Only couple close friends
8. May act impulsively without considering consequences	8. May think unnecessary profoundly without any concrete results
9. Impatient with long and slow projects	9. Has patience for slow projects
INFORMATION GATHERING (7 items)	
Practical (sensing):	***Creative (intuition):***
1. Thinks facts and details	1. Thinks concepts and interdependencies
2. Prefers practicality	2. Prefers imagination
3. Lives in current time	3. Lives in future
4. Likes clearly measurable things	4. Sees opportunities
5. Works systematically step by step	5. Works impulsively and moves flexibly from one thing to another
6. Form an overall picture by collecting the pieces together	6. Tries to fit the pieces to the entity
7. Likes functioning routines	7. Likes change and variation
DECISION-MAKING (7 items)	
Analytical (thinking):	***Beliefs (feeling):***
1. Decisions based on reason	1. Decisions based on feelings
2. Logical	2. Personal values
3. Truth	3. Harmony
4. Critical	4. Tolerant
5. Observes	5. Participates
6. Good in analysing	6. Good in understanding
7. May seem as cold and distant (from others)	7. May seem as emotional (from others)
APPROACH TO ENVIRONMENT (7 items)	
Structured (judgment):	***Flexible (perception):***
1. Organized lifestyle	1. Flexible lifestyle
2. Order, structure, plans	2. Let´s see what will happen
3. Control	3. Curiosity
4. Decision, execution, next task	4. Keeps options open (shifted decision)
5. Clear limits and instructions	5. Searching new, going beyond limits
6. Schedules and anticipation	6. Last moment rush
7. May seem stiff and inflexible	7. May seem unorganized and confused

THE STUDY OF EL FEATURE IMPLEMENTATION IN THE KM PERSPECTIVE

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ABSTRACT

The word of "e-Learning (EL)" has become common in these days. Delivery of learning materials and learning evaluation are relatively convenient and efficient with the use of widely-spread internet. EL happens to be a popular tool in higher education for enhancing learning capability. While knowledge management (KM) is recommended as a strategy to ensure that information and knowledge reaches the right people at the right time in the right format and to share them for improving the overall performance. Both KM and EL address the same basic goal, which is facilitating for improving learning performance. But, they approach the same problem with different paradigms. Indeed, KM and EL are complementary to each other, especially in the academic institutions. KM requires EL system to enhance KM effectiveness whereas EL has to improve its performance by the KM process. Therefore, the KM based e-Learning: the integration between KM and EL, one of interesting concepts for enhancing EL performance based on KM concept is proposed in this study.

In the KM perspective, EL is not only recommended as a KM tool for transferring knowledge but also a knowledge repository for storing, sharing and reusing knowledge. KM can enhance EL performance by applying effective supporting EL features. Therefore, universities should to implement EL features based on KM concepts such as knowledge transfer/sharing/exchange tools for supporting collaborative learning. However, enhancing EL performance by implementing only EL features may overlook the importance of the social aspects. EL features are just only supporting tools not solutions to improve knowledge sharing/exchanging within and between learners and learning networks. Learning materials cannot replace the deep tacit knowledge of human beings. Therefore, universities also have to implement supporting learning policies and activities to encourage and support lecturers and students to use their learning management system (LMS) more efficiently and open their mind to share knowledge with others.

Keywords: e-Learning, Knowledge Management

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INTRODUCTION

Many universities have adopted ICT and networking to support traditional classroom instruction by calling this new learning environment “e-learning” (electronic learning or EL). E-learning refers to the use of information and communications technology (ICT) to enhance and/or support learning activities (OECD, 2005). E-learning systems provide fulltime learning services that students can access and learn without requiring their physical location. The benefit of e-learning is to provide cost-effective ways of education and to improve quality of learning (Cloete, 2001). EL also focuses on learner-centered activities and system interactivity.

EL technology has been utilized in university since the end of last decade by using the information and communication technology as a key driver. The implementation of EL in universities is quite diverse based on university’s policy and basic technological infrastructures. Therefore, the issue of how to facilitate the information and communication technology for enhancing learning performance was not clear at that time.

In Thailand, students paid high respect to the lectures as the main and only source of knowledge, regardless of other learning resources. The person-to-person teaching in the traditional classroom has been the main instructional method for a long period of time. Person-to-person teaching is always referred as the best method for transferring knowledge from lecturers to students. As a result, the substitution of EL to conventional classroom teaching in Thailand cannot be as simply implemented and obtained satisfied and expected results as in other western countries.

As such, knowledge management (KM), the ability to create, store, transfer, and use knowledge, is likely to play a significant role to improve learning activities. In recent years, KM issues have acquired utmost importance in all sectors, especially in the sector of learning activity. The use of KM as a supporting strategy for EL is found related to increasing the learning capability. KM is becoming an even more critical to learning organizations for enhancing their learning performance. In summary, KM is recommended as one of interesting learning catalysts for EL. However, the relationship between KM and EL has not yet been fully understood and harnessed. Therefore, implementing KM to support learning activities in EL is also an interesting issue.

In this study, the EL features are considered as elements in knowledge management system for analyzing in the KM perspectives. The objectives of this study are to explore the usage of EL features of LMS used in Kasetsart University in Thailand and in the KM perspective and to propose recommendations how to improve their e-Learning performance by focusing on a systematic KM.

E-LEARNING AND KNOWLEDGE MANAGEMENT

e-Learning definition

Henry (2001) defined EL as an appropriate application of the internet to support the delivery of learning, skills and knowledge not limited to any particular courses, technologies, or infrastructures. Rosenberg (2001) also suggested that EL is the use of the Internet to deliver a broad series of solutions that increase knowledge and performance. Whereas Gunasekaran et al. (2002) referred to EL as Internet-enabled learning comprising of content delivery in multiple formats, the management of the learning experience, and a networked community of learners, content developers and experts. E-learning refers to the use of information and communications technology to enhance and/or support learning activities. E-learning also refers to both wholly online provision and campus-based or other distance based provision supplemented with ICT (OECD, 2005). In this study, EL is defined as innovative approaches that not only education delivery of learning contents via electronic forms of information that enhance the learner's capability, but also evaluation and personalization.

EL features: Online environment and EL features were also mentioned as a factor contributing to the success of EL. According to Fabry and Higgs (1997), the Internet access and its availability were claimed by the university teachers to be critical factors to the uptake of web-based instruction. Internet technology improvement and convenience to the access are perceived by faculty members and students to be the key to the success of EL system (Fabry and Higgs, 1997; Daugherty and Funke, 1998).

Many additional EL features have been designed and implemented to support and enhance learning activities for improving the performance of LMS. For example, Kim (2004) introduced a metadata for collaborative work and learning specific to video editing and authoring activity. Tamura et al. (2003) have also proposed a metadata CLEM (Collaborative Learning Entity Metadata), which describes static entities of collaborative learning. The communication technologies are usually integrated in several LMS to support asynchronous and asynchronous discussion board, shared whiteboard, and chatroom for exchanging information and knowledge among learners in learning networks. Tamura and Hirasawa (2006) conducted a metacognition acquisition support system as a feature to support problem-solving learning skill. There are several EL features in LMS for enhancing learning capability. However, different LMS tools may provide different EL features depend on LMS developers, usage objectives, and prices. Therefore, the characteristics of EL features are very important factors for university to select and implement in its LMS for supporting its learning activities and achieving learning objectives.

Knowledge Management and e-Learning

KM consists of several processes namely knowledge identification, knowledge acquisition, knowledge utilization, knowledge development, knowledge integration, knowledge transfer, and knowledge storage and maintenance (Numprasertchai and Igel, 2004). KM is also related to an organizational perspective, because it usually addresses the lack of sharing

information and knowledge among members by encouraging the individuals making their knowledge explicit which can be stored in knowledge repositories and share with others in learning communities. Whereas, EL emphasizes an individual perspective, as it usually focuses on the individual to access and acquire new knowledge for improving their capability through the Internet technology.

Many KM studies have addressed learning mostly as part of knowledge transfer/sharing process and focuses on specific forms of informal learning or on providing access to learning resources or experts. On the other hand, learning might also benefit from KM technologies. In the relationship between KM and EL, Poovarawan et al. (2006) suggested that EL is one of ICT based KM tools for enhancing university competitiveness. It is not only enhancing learning capability but also supporting university to manage a mandate in term of teaching/learning activities more efficiently. Therefore, a LMS should take into account the relationship between knowledge management and learning based on different learning environment.

CONCEPTUAL FRAMEWORK

Based on the previous studies, we assess and analyze the LMS of Kasetsart University (KU) by focusing on EL features in the KM perspectives. This is because Kasetsart University, one of Thailand's largest and most progressive public universities, has implemented its own LMS system namely "M@Xlearn" and used it as an e-learning support system for supporting learning activities since 2000. More than 44,000 students in undergraduate and postgraduate programs in four campuses have used this LMS in each year. This study focuses on the investigation into EL features that influence the implementation of contents and services in LMS and impact to learning capability. This study is also to propose various learning activities based on KM perspectives for enhancing LMS performance.

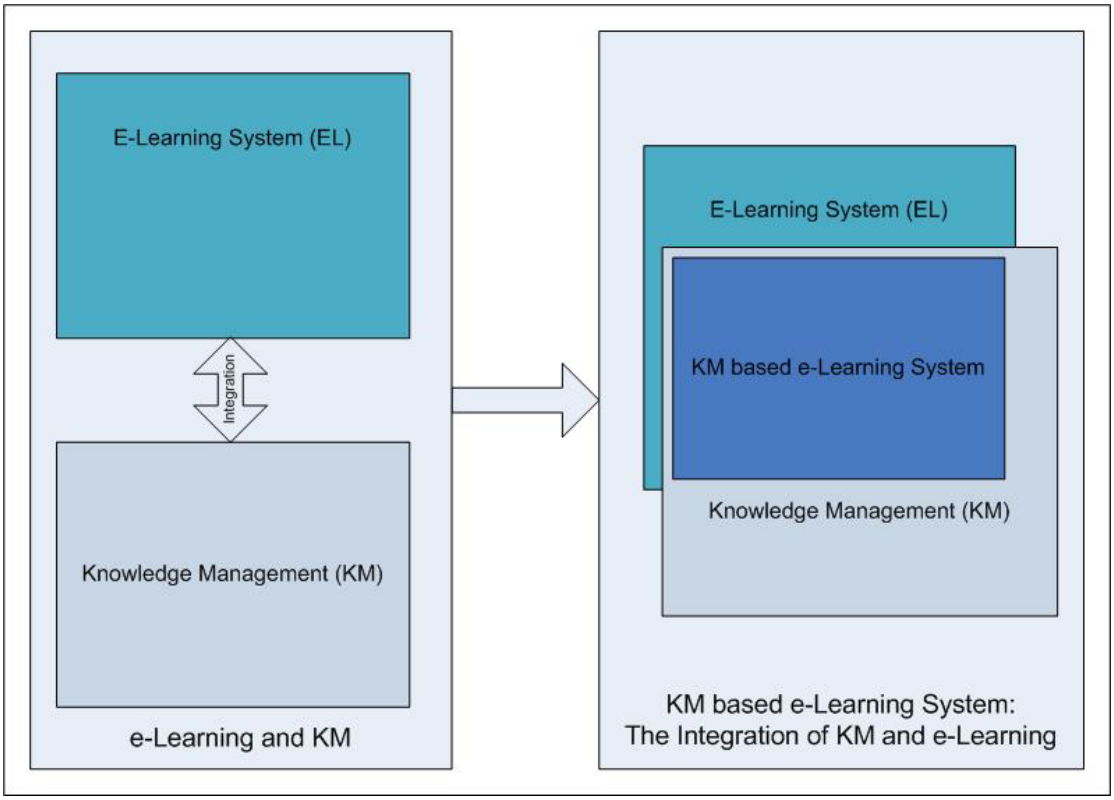

Figure 1 KM based e-Learning: The implementation of EL features based on KM concepts

METHODOLOGY

The study of e-Learning usage in KM perspective is quite new and there is only scattered empirical evidence. The case studies, a qualitative data collection method, was used to gain in-depth insights into the managerial practice of implementing EL features based on KM concepts in LMS used in Kasetsart University in Thailand. The reason for this approach is that there is an unclear boundary between KM and EL.

In this study, the implementation of EL usage and features of LMS of Kasetsart University was selected as case studies. The analysis was based on qualitative information that analyzed the EL usage and features affecting LMS performance based on the KM perspective. The findings and final results were reviewed and analyzed by educational experts, senior lecturers and executives.

RESULT AND DISCUSSIONS

EL Usage in KU

M@XLearn is Kasetsart University's powerful EL suite. Numprasertchai and Poovarawan (2007) suggested that M@XLearn is one of knowledge enabling tools in KM@KU4Learning which supports university's mandate in term of teaching and learning activities. This EL system has been implemented by researchers of the Faculty of Engineering to support e-University policy. The reason to create its own system is convenience to implement new and required features as request by lecturers or university's policy. There are numbers of

courses in M@XLearn for undergrad and graduate students. Students can learn, communicate with their lecturers and classmates, and submit their assignments through this e-learning system.

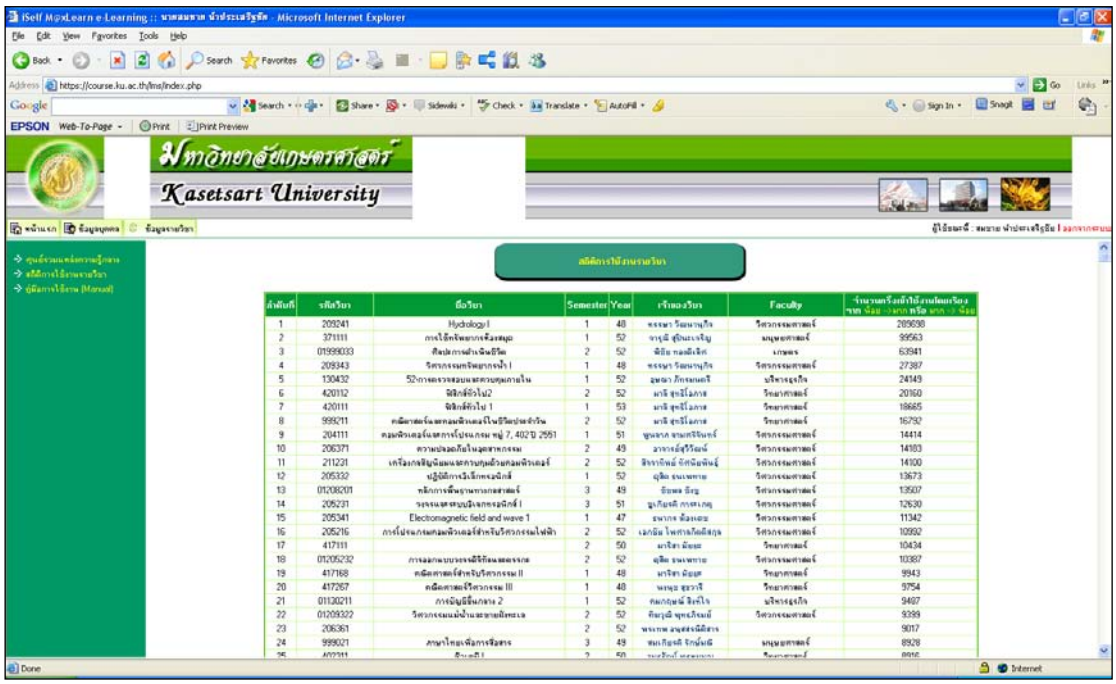

Figure 2 M@XLearn: A powerful EL suite of Kasetsart University

EL system helps lecturers manage their teaching resources and course schedule more conveniently and efficiently. Most KU lecturers have managed their course and class materials through this EL system. M@XLearn is not only LMS system for KU students but also one of commercial products of KU. M@XLearn has also been sold to other universities and the private sectors in Thailand.

Table 1: EL Characteristics in Kasetsart University.

Characteristics	M@XLearn (EL of Kasetsart University)
Type of university	Public university
Nation	Thailand
Class attendance	Required
Status of EL unit	R&D: Computer Center of Faculty of Engineering Operation: A workgroup in Office of Computer Service (OCS)
EL platform	In-house development (M@XLearn)
Responsibilities of EL unit	Provide training for instructors IT infrastructure matters EL system administration
Instructor's role	Content provider Online activities design Presentation design Online assessment Communication design
Instructor's incentives	Credited as an academic output Social recognition
Total classes in EL	Around active 2,000 courses
Major content in EL	"PowerPoint" presentation Syllabus Lecture notes in documentation Links to other learning resources Additional learning materials
Main objective of EL adoption	Enhance the in-class instruction Reuse of class material
Implementation Features	Initiatives are from individual instructors with limited supports
Level of integration of EL into the F2F teaching	Moderate integration in varied styles

EL Features

Internet access is becoming a basic requirement for learning in the university level. Lecturers and students of KU can access their LMS through the Internet more convenience through wireless and wire-line system by using computer services at computer centers in universities or their own mobile computers, and so on. Therefore, lecturers and students can access these LMS through the Internet from anywhere in anytime. Therefore, EL features of LMS are considered as main factors for success or failure in e-Learning system. Based on the study on LMS used in Kasetsart University and general EL system such as Moodle, there are several common features to support learning process show in the Table 2.

Table 2: EL features in EL system of KU and general EL system (Moodle).

EL features	M@xlearn (KU)	General EL system
Communication Tools		
Discussion Forums	√	√
File E-change	-	√
Internal Email	√	√
Online Journal/Notes	Link to the library system	-
Real-time Chat	√	√
Productivity Tools		
Orientation/Help	√	√
Searching Within Course	-	√
Calendar/Progress Review	√	√
Student Involvement Tools		
Group work	-	√
Self-assessment	√	√
Student Community Building	-	-
Student Portfolios	Link to student system	-
Administration Tools		
Authentication	√	√
Course Authorization	√	√
Registration Integration	Link to registry database system	-
Hosted Services	√	√
Course Delivery Tools		
Course Management	√	√
Instructor Helpdesk	√	√
Online Grading Tools	Link to KU Grading system	-
Student Tracking	√	√
Automated Testing and Scoring	√	√
Curriculum Design		
Accessibility Compliance	-	√
Course Templates	√	√
Curriculum Management	-	-
Customized Look and Feel	-	√
Instructional Standards Compliance	-	√
Instructional Design Tools	√	√
Content Sharing/Reuse	√	√

Kasetsart University has developed its own Learning Management System (LMS) called M@XLearn. EL features in this M@XLearn have been implemented and modified by administrators of the Computer Service Center of faculty of Engineering based on request and university's policy. For example, some EL features have been developed by creating links to another service system for reducing the redundancy such as student portfolio, online journals, and registration integration.

EL Features in KM perspectives

Based on the study on EL features used in Kasetsart University, several EL features support not only learning processes but also KM processes. Therefore, if the KM processes can be managed and improved, the more efficiency in EL processes will be improved. In this KM based EL system, EL features are considered as enabling tools for supporting lecturers and

students to identify, acquire, transfer, development, integration, use and store knowledge more efficiency for achieving learning achievement.

Table 3: The relationship between KM process and EL features/module.

KM Processes	EL Features/Modules
Knowledge identification	External links, Search within course
Knowledge acquisition	External links
Knowledge utilization/reuse	Self-assessment, Quiz module, Content sharing/reuse
Knowledge development/integration	Lesson module, Student community, Group work, White board, Discussion forums, Real-time chat, File exchange,
Knowledge transfer	Student portfolio, Student community, Group work, White board, Discussion forums, Real-time chat, File exchange
Knowledge storage/maintenance	File site storage

Knowledge identification

Knowledge identification is the process to identify the existing learning material and sources of knowledge required for each course. Web link and search within course in M@Xlearn and general EL system are the EL features related to knowledge identification. Students in both universities always search and access all required information and knowledge through these features.

Lecturers should identify a clear learning scope and objective in each course. They have to create a specific course portal using external link to help student to access useful learning materials from external resources more easily for achieving the learning objectives. EL features in M@Xlearn are easier for creating links for this purpose. Therefore, EL features in both LMS are fully support knowledge identification.

Knowledge acquisition

Knowledge acquisition is the process to obtain required knowledge from external sources to fill existing material developed by instructor. For EL course using M@Xlearn, lecturers have to create their links as a specific course portal to connect their class to various learning material from internal and external sources.

LMS in KU has been implemented to support an exchange standard “the Shareable Content Object Reference Model (SCORM)”. Therefore, they can acquire exchange and distribute learning material with other education institutes. Therefore, the improvement of knowledge acquisition depends on the quality of course portal defined by lecturers and quality of internal and external learning sources rather than EL features. Lecturers have to identify and select internal and external learning sources more carefully. They also have to encourage students to access and learn from external learning material.

Knowledge utilization/reuse

Effective knowledge utilization is needed for making better decisions to select the right learning material and knowledge from internal and external sources for teaching courses. Lecturers in KU can access and modify the teaching materials based on the class evaluation

from students and comment from peer-reviewed by other lecturers in the same and relate teaching area. They can use their own previous teaching materials as core teaching materials for current and future course. EL features help lecturers reduce time to prepare teaching materials. Some high quality and market potential teaching materials have been transformed to commercial textbook.

Knowledge development/integration

Knowledge development is the process to develop new knowledge through creating new teaching materials. While knowledge integration is a process to integrate knowledge from several sources for creating new knowledge is necessary to conduct the more complex teaching materials.

There are several EL features in both LMS in KU support a knowledge development process such as a lesson module white board, discussion forums, and real-time chat. However, many lecturers use their own previous electronic teaching materials without any changes. This is a reason why EL cannot support a knowledge development process and enhance students' learning capability.
University has to develop teaching strategies or policies to solve this problem by encourage lecturers to improve their teaching materials continuously. For example, Faculty of Engineering of KU has a supporting policy to encourage lecturers to develop new teaching material or improve the quality of previous teaching material and then publish as a commercial textbook by providing supporting funds and awards.

EL features also support students can improve their knowledge and skills through personalization by learning from each others in the learning communities by using real-time chat, whiteboard and discussion forum in LMS. However, most students don't want to discuss and exchange their knowledge and learning materials with the others. Lecturers should view statistical summaries of discussions displaying participation and encourage students to create more discussion groups and learning communities for group learning. In the strategic level, university has to improve the performance of knowledge development and integration by encourage lecturers to teach based on student-centric system.

Knowledge transfer

Knowledge transfer can be categorized as internal knowledge transfer among students and external knowledge transfer focusing on transferring knowledge to the public. Knowledge transfer does not only include transfer, sharing, and exchanging knowledge among people. Knowledge transfer is necessary for all learners.

Several EL features in LMS support a knowledge transfer process not only transfer knowledge from lecturers to students but also transfer knowledge among learners and lecturers such as student community, group work, white board, discussion forums, real-time chat and file exchange.

In this knowledge transfer process, lecturers can improve its potential by building informal learning communities in their EL course to encourage their students to share knowledge, individual learning material, and ideas with the others.

Knowledge storage and maintenance

Knowledge storage and maintenance is the process to preserve and validate learning material and knowledge for reuse and sharing. The aim of this KM process is to collect and maintain the knowledge in the organization. So that it is not loss if lecturers resign or retire. The stored knowledge and teaching material are vital to the present performance of the organization, and provide an important source for new knowledge development.

Knowledge storage and maintenance is necessary to support lecturers to share knowledge among their co-teaching teams and students. Database in EL system also help lecturers shorten teaching material implementation time. However, many lecturers in KU are also worry about the reliability and security of LMS. Therefore, they don't want to locate their overall teaching materials in LMS. EL unit have to manage trust between lecturers and the reliability of LMS.

CONCLUSION

Knowledge Management (KM) is essentially connected to the learning activities as strategies or processes for students to acquire, share, integrate, and use the various knowledge sources in their learning process for enhancing their learning capability. All KM processes are embedded in the EL activities. Each KM process is supported by several EL features. Some EL features support various KM processes such as discussion forum supports knowledge transfer, sharing, development and integration.

Especially, knowledge identification, acquisition, transfer development/integration, reuse and sharing were found to be the key processes which can enhance students' learning capability. Effective knowledge identification helps students to understand the learning scope and objectives clearly. Knowledge identification and acquisition also helps lecturers and students to identify and access required information and knowledge from various internal and external sources which relate to learning topics more conveniently. Knowledge development/integration support lecturers/students to improve their individual knowledge and skills by learning from several sources and learning communities. Knowledge transfer/sharing/reuse support students to improve their learning capability by learning from the others. Knowledge storage helps university collect and store teaching materials and knowledge although lecturers retired.

This study's findings indicate that it is crucial to implement EL system through integrate EL features which support KM processes for enhancing teaching and learning capability. With the specific implications above, it is hoped that this study will contribute to the continued development of EL in other educational institutions.

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2nd Parallel Sessions

Wednesday June 29, 2011
15:20 – 17:00

A2 – Customer satisfaction

A2.1 **Application of improved CFI model on attributes of customer satisfaction**
Alemu Moges Belay

A2.2 **An evaluation of virtual and physical shopping process on consumer price sensitivity: innovativeness as a moderator**
Kit Hong Wong

A2.3 **Customer intimacy in online personalized recommendation**
Dr. Ting-Peng Liang

A2.4 **Personalized advertizing recommendation based on web mining and chance discovery**
Tsung-Hsien Wu

A2.5 **How e-servqual affects customers online purchase intention through cross-culture comparison?**
Shu-Chiung Lin

APPLICATION OF IMPROVED CFI MODEL ON ATTRIBUTES OF CUSTOMER SATISFACTION

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ABSTRACT

The purpose of the study is to develop and apply improved model of Critical Factor Index (CCFI) on customer satisfaction in one of service provider in Finland. CCFI method is selected because it is comprehensive, practical, and considers the standard deviation and sees also the gap between the customer expectation and experiences. After the description of the method the current pitfalls of the model will be explained by comparing the existing CFI to the newly developed CCFI (corrected critical factor index). From the result of the study, the company identified the area to be improved based on the criticality of the attributes and give insight to balance the resource allocations accordingly. The methodology is Questionnaire/survey with relevant attributes and 150 responses are gathered with required information (15 are analyzed in this paper). The main motive of the paper is that, the old model doesn't consider the influence of number of responses whereas the new model takes in to consideration and bring some non-zero results. This helps managers to see the relative gap when one of the standard deviation (experience and/or expectation) becomes zero. Besides to that this paper introduces how control chart could help on identifying green, yellow, and red section based on the criticality of the attributes. Finally emphasized implementation index and its correlation will be presented.

Keywords: Corrected Critical Factor Index; CCFI, Customer satisfaction; Control chart, Service.

INTRODUCTION

No matter the type of services/products you are providing, decision making is done at any stage in the process. So, strategic service management of an organisation ought to have a sagacious view about the current situation and future improvement and development possibilities. Nowadays, service engineering has become an increasingly important part field of study to contribute to global economy. Enhancing service productivity become crucial as service sector becomes more knowledge based and service based. Substantial studies show that excellent service is widely recognized as a decisive factor on different business environment (Voss et al., 2004a; Vilares and Coehlo, 2003). According to (Newman and Cowling, 1996), service sector and quality is "essential to corporate profitability and survival" and Rosen et al., (2003) described as "not just a corporate offering, but a competitive weapon". Voss et al., (2002) and Johnston, (1959) indicated the complexity of service quality concept in service sector and there is no clear picture on the drivers for delivering in effective way.

final draft

Due to globalization and other factors the nature of competition in services is changing and unpredictable in some cases because the forces of deregulation and new technologies have restructured service industries in recent years. Therefore managers are always looking for the better way of doing things by implementing different approaches to tackle these challenges. For instance applying decision making indicator like CCFI can be taken as example. This added flexibility would help to ensure that the product or service delivered meets the customer's requirements and specifications. Another tool which is helpful for decision making is CFI which finally improved to CCFI. CFI method is a t tool to indicate which attribute of a business process is critical and which is not, based on the experience and expectations of the company's employees, customers or business partners (Ranta, Juha-Matti & Josu Takala, 2007).

In order to make the appropriate decision managers has been using several decision supporting tools. That is why the CFI (Critical Factor Index) has been developed to make a decision making in comprehensive way of current performances of business processes based on expectation, experience, competitor and other attributes. This tool indicates which attribute of a business processes or activities are critical and which are not. The CFI was developed on the basis of the Gap analysis and the implementation index (IMPL). The original idea, behind these measurement tools, was to develop a fast and reliable method for management purposes to sense and respond to customer satisfaction. Even though the method helps and applied on many different cases on identifying which attributes are critical within the business process and supports the management to make decisions on identifying which attributes should be improved. Having well defined attributes, the method can be used to measure all business processes and activities. As a weakness, CFI indicator is highly influenced by the standard deviation and it doesn't show the magnitude of the attributes if one of the standard deviation (expectation and/or experience) is zero. (Ranta, Juha-Matti & Josu Takala, 2007) also proposed in their case study about further development of the CFI in order to increase the reliability of the findings. This paper tries to avoid zero CFI and introduce a formal way of identifying three distinct areas (green yellow red). Then the method will be improved from CFI to CCFI that will avoid the non-zero deviation by integrating the sample error correction.

DRIVER FOR SERVICE ATTRIBUTES

Recently all type of businesses including service have become under extreme pressure to provide services to the client/customer quicker than ever before. With such an extreme pressure being applied to respond and implement services faster than ever before, companies that provide service can no longer afford or survive to perform work with limited resources or in non-reactive/responsive way to customers. For the last few decades, three factors Speed, quality, low cost is universal goals as long as there has been competition in any service and other business. There are many resource wastes in service sectors that directly affect the customers' attitude towards service provider. Minimizing the major resource wastes of the services and reducing complains of customers' need continuous and consistent endeavor. This is because seeing service through ones eye is not as an easy task as we expect in order to be a customer centered service organization. The big challenge in service is to identify, analyze and developing capability to understand service resource waste in systematic and organized way. Some of the wastes could be categorized in few

major areas like, over processing, transportation, motion, inventory, waiting time, defect, over-production, and information. One of the motives of this paper is to introduce the possibility of reducing resource waste linked with resource allocation based on the critical level of each attributes. In order to see and analyze in detail, these major attributes could be broken down in to several attributes and treated individually and based on the criticality it would be possible to balance the resources distribution. Having well defined attributes for each specific companies and situations, CFI would lead to right decision for optimum utilization of resources.

CCFI DETERMINATION IN SERVICE GIVING COMPANY

The case company is one of a strategic partner that provides mainly services and products to some extent. Its customers for long term services are from both domestic and international industries. The company is ISO certified and with a capability of peculiar products based on customers requirements and specifications. To carry out this research, questionnaires (sample table 1) with relevant attributes are used to gather the relevant information. As a matter of fact, each services and processes have its own attributes and it is difficult to have a single standardized questionnaire. Usually this is done in two phases. On the first phase the current performance of the services is investigated, personnel interviews and discussion will be made to come to common agreement on defining attributes which are going to be set. To achieve the overall objective, proposing development needs for certain attributes, the choice for them should be in line with the company's own strategy, vision, mission and values. In the second phase, all information that has been gathered will be analysed and critical factor index (CFI) measurement tools will be applied to determine the critical attributes that needs improvement. This will give an idea for managers to decide on balanced resource allocation in various activities of services.

Table 1: Sample questionnaire.

	Expectations	**Experiences**	**Compared with competitors (Please tick your option)**			**Direction of development (Please tick your option)**		
	(1-10)	(1-10)	Worse	Same	better	Worse	Same	better
Attribute 1	[ ]	[ ]	☐	☐	☐	☐	☐	☐
Attribute 2	[ ]	[ ]	☐	☐	☐	☐	☐	☐
•	[ ]	[ ]	☐	☐	☐	☐	☐	☐
•	[ ]	[ ]	☐	☐	☐	☐	☐	☐

Expectation = what is the expectation to the attribute
Experience = what is the experience of the attribute
Compared with competitors = Compare experienced value to the values of all other targets
Direction of development = Direction of the experienced values of the sample during the last three years.

$$\textbf{CFI} = \frac{\text{Standard dev. of expectation} * \text{Standard deviation of experience}}{\text{Importance index} * \text{Gap index} * \text{Direction of development index}}$$

$$\text{Gap index} = \left| \frac{\text{Average of the experience} - \text{Average of the expectation}}{10} - 1 \right|$$

$$\text{Direction of Development index} = \left| \frac{\text{Dir. of Devt. Better\%} - \text{Dir. of Devt. Worse\%}}{10} - 1 \right|$$

Importance index = $\frac{\text{Average of expectation}}{10}$

In the CFI model was applied in many applications on Quality, Maintenance, production, Knowledge management and etc. But the existing model would be a good critical factor identifying tool and appropriate when one of the standard deviations or both are non-zero. In order to improve the situation the sampling error correction can be taken from the model which is developed by miller (1955) and Basharin (1959) who derived an approximation for the expectation of a sampled uncertainty, AE(Hnb), that would be good for large sample n. The new developed model critical factor index with sample error correction (CCFI) can be rewrite as follows:

AE (Hnb) =Hg-$\frac{s-1}{2\ln(2)n}$

CFI = CCFI - S_{EC}

CCFI= CFI + $\frac{s-1}{2\ln(2)n}$,

Where s is the minimum number of sample in our case 3, and n is the number of sample (responses) actually analysed.

CCFI = $\frac{\text{Standard dev. of expectation} * \text{Standard deviation of experience}}{\text{Importance index} * \text{Gap index} * \text{Direction of development index}} + \frac{s-1}{2\ln(2)n}$

DATA ANALYSIS, RESULTS AND INTERPRETATION

The physical meaning of adding sampling error is to avoid zero CCFI. That is because with certain amount of input (resource) there must be some output in all extremes i.e. high critical or low critical. Unfortunately in our data analysis we did not get a zero STD on experiences and/or expectation. In such situation it may not be visible the significance of sampling error correction as all attributes have its own critical values. The essence of incorporating sampling error is to tackle the probability of getting zero CCFI. As we know the probability of having zero STD deviation is high as sample size goes lesser and lesser. A person collecting 100 responses and a person with 3 should not apply the same parameters and analysis. So, in this research the gap will be filled by balancing CFI by adding some value that takes the number of responses in to account. Control charts have been used for several applications and here we have used to identify the critical level or area. These help managers to clearly observe and answer which attribute, at what level and how much they are critical. Besides to that by varying different attributes level it could be possible to adjust the other attributes. For example, by reducing or increasing some values on most critical ones it would be possible to see the overall critical level change. In our case, if the company reduce the critical level of attribute 18 and 25 into 2, the lowest critical could become in to the green area. That means it could be possible to have significant influence on attribute 2, 3, 6 and 13 that they become in green area. In general out of 43 attributes, 6 each were in both extremes and the rest were in green areas.

Table 2: Results of the preliminary analysis.

No.	Average of expectation	STDEV of expectation	Average of experiences	STDEV of experiences	Gap index	Direction of development index	Importance index	COMP	IMPL
1	9,25	0,5	7	1,25	1,2250	1,0000	0,9250	0,7	1,785714
2	9,25	0,5	7,5	0,58	1,1750	1,0000	0,9250	0,75	0,773333
3	9,25	0,5	7,5	0,58	1,1750	1,0000	0,9250	0,75	0,773333
4	9	0,82	7,75	1,26	1,1250	0,5000	0,9000	0,775	1,625806
5	9,5	1	7,25	0,96	1,2250	0,5000	0,9500	0,725	1,324138
6	8,25	0,25	7,25	0,96	1,1000	1,0000	0,8250	0,725	1,324138
7	9,75	0,5	7	1,83	1,2750	1,0000	0,9750	0,7	2,614286
8	9,75	0,5	7,25	1,71	1,2500	1,0000	0,9750	0,725	2,358621
9	8,75	0,96	7,75	1,5	1,1000	1,0000	0,8750	0,775	1,935484
10	8,75	0,96	7,25	1,26	1,1500	1,5000	0,8750	0,725	1,737931
11	8,5	1	7	1,15	1,1500	1,0000	0,8500	0,7	1,642857
12	8,5	1	7	1,15	1,1500	1,0000	0,8500	0,7	1,642857
13	8,25	0,5	7,5	0,58	1,0750	1,0000	0,8250	0,75	0,773333
14	8,5	1	8,5	1	1,0000	0,5000	0,8500	0,85	1,176471
15	8,5	1	7,5	1,29	1,1000	1,0000	0,8500	0,75	1,72
16	8,5	0,96	8,00	1,15	1,0500	1,0000	0,8500	0,8	1,4375
17	8,75	0,96	7,25	0,96	1,1500	1,0000	0,8750	0,725	1,324138
18	8,75	0,96	8,25	1,71	1,0500	0,5000	0,8750	0,825	2,072727
19	9	0,82	7,75	1,26	1,1250	0,5000	0,9000	0,775	1,625806
20	9	0,82	7,75	0,96	1,1250	1,0000	0,9000	0,775	1,23871
21	8,75	1,26	7,75	0,96	1,1000	1,0000	0,8750	0,775	1,23871
22	9,25	0,5	7,25	0,5	1,2000	1,5000	0,9250	0,725	0,689655
23	9	0,82	6,75	0,96	1,2250	1,5000	0,9000	0,675	1,422222
24	9,5	0,58	7,5	1,73	1,2000	0,5000	0,9500	0,75	2,306667
25	8,75	0,96	7	2	1,1750	0,5000	0,8750	0,7	2,857143
26	8,5	1	7	1,41	1,1500	1,0000	0,8500	0,7	2,014286
27	8,5	1	7,5	0,58	1,1000	1,0000	0,8500	0,75	0,773333
28	9	0,82	6,5	2,38	1,2500	1,0000	0,9000	0,65	3,661538
29	9	0,82	7,75	0,96	1,1250	1,0000	0,9000	0,775	1,23871
30	9,5	0,58	7,5	0,58	1,2000	1,5000	0,9500	0,75	0,773333
31	9	0,82	7,25	0,5	1,1750	0,5000	0,9000	0,725	0,689655
32	9,5	0,58	7,5	1	1,2000	1,0000	0,9500	0,75	1,333333
33	9,25	0,5	8	1,15	1,1250	0,5000	0,9250	0,8	1,4375
34	9,25	0,96	8	0,82	1,1250	1,0000	0,9250	0,8	1,025
35	9,25	0,96	7,75	0,96	1,1500	1,0000	0,9250	0,775	1,23871
36	9	1,41	7,75	0,58	1,1250	0,5000	0,9000	0,775	0,748387
37	9,25	0,96	7,5	1	1,1750	1,0000	0,9250	0,75	1,333333
38	9	0,82	7	1,15	1,2000	1,5000	0,9000	0,7	1,642857
39	9	0,82	6,75	0,96	1,2250	1,5000	0,9000	0,675	1,422222
40	8,75	1,5	6,75	0,96	1,2000	1,0000	0,8750	0,675	1,422222
41	8	1,41	7,25	0,96	1,0750	1,0000	0,8000	0,725	1,324138
42	9	1,41	5,75	1,26	1,3250	2,0000	0,9000	0,575	2,191304
43	9	0,82	6,25	0,96	1,2750	2,0000	0,9000	0,625	1,536

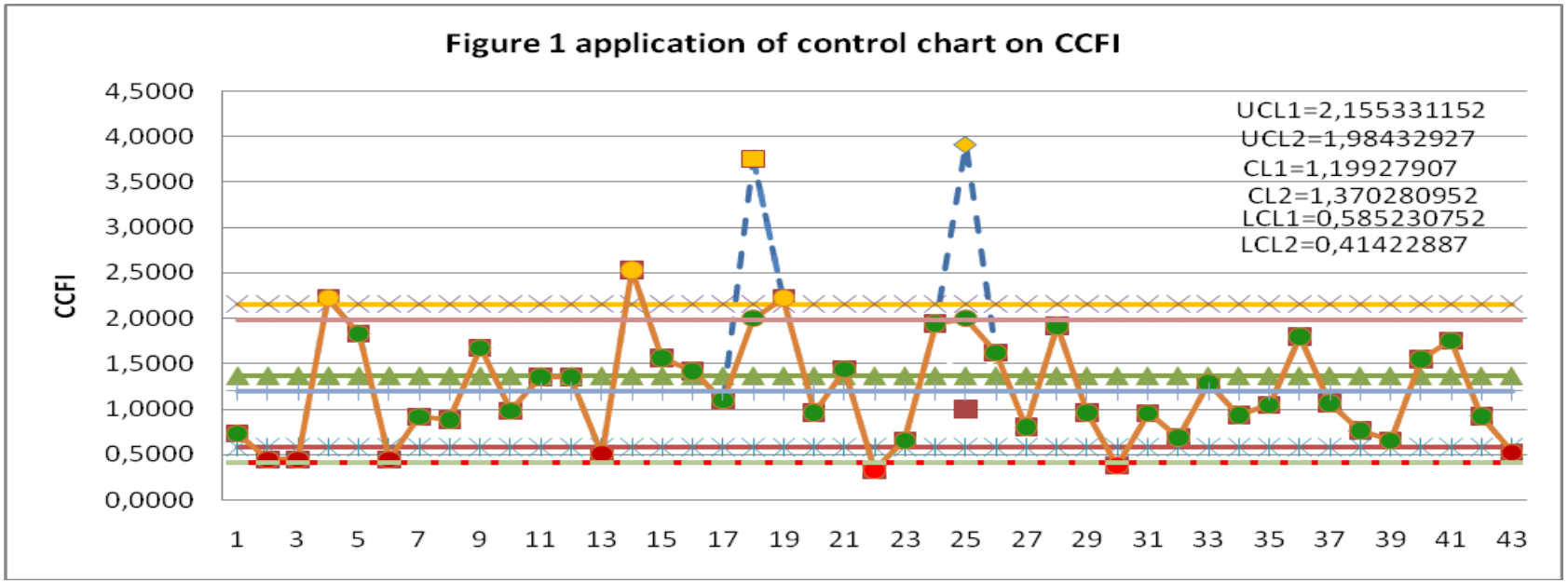
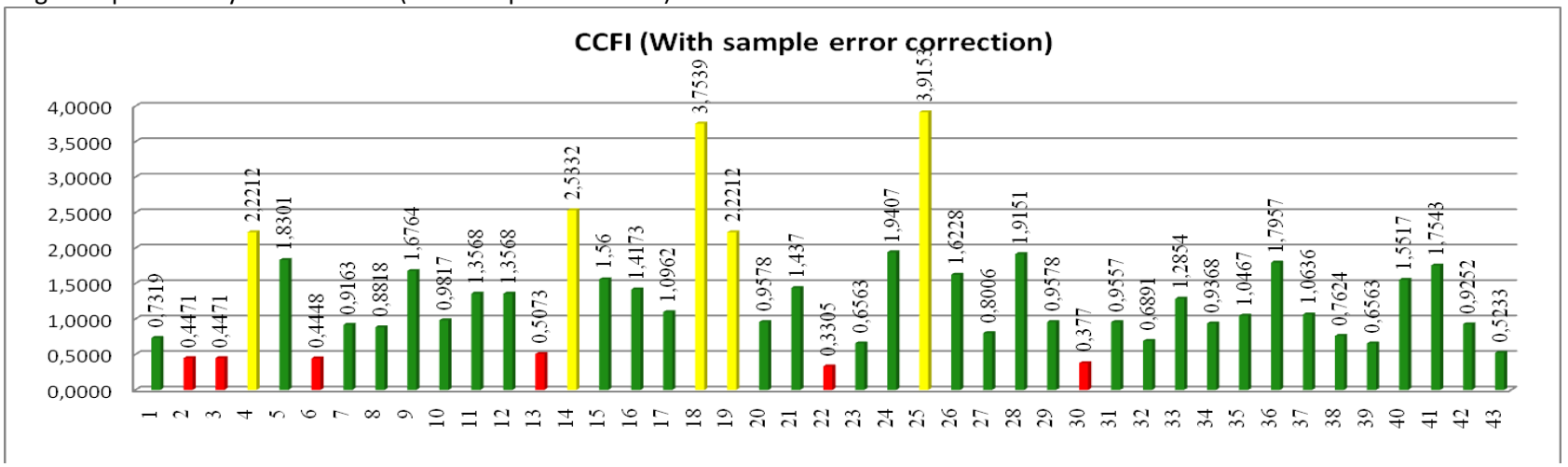
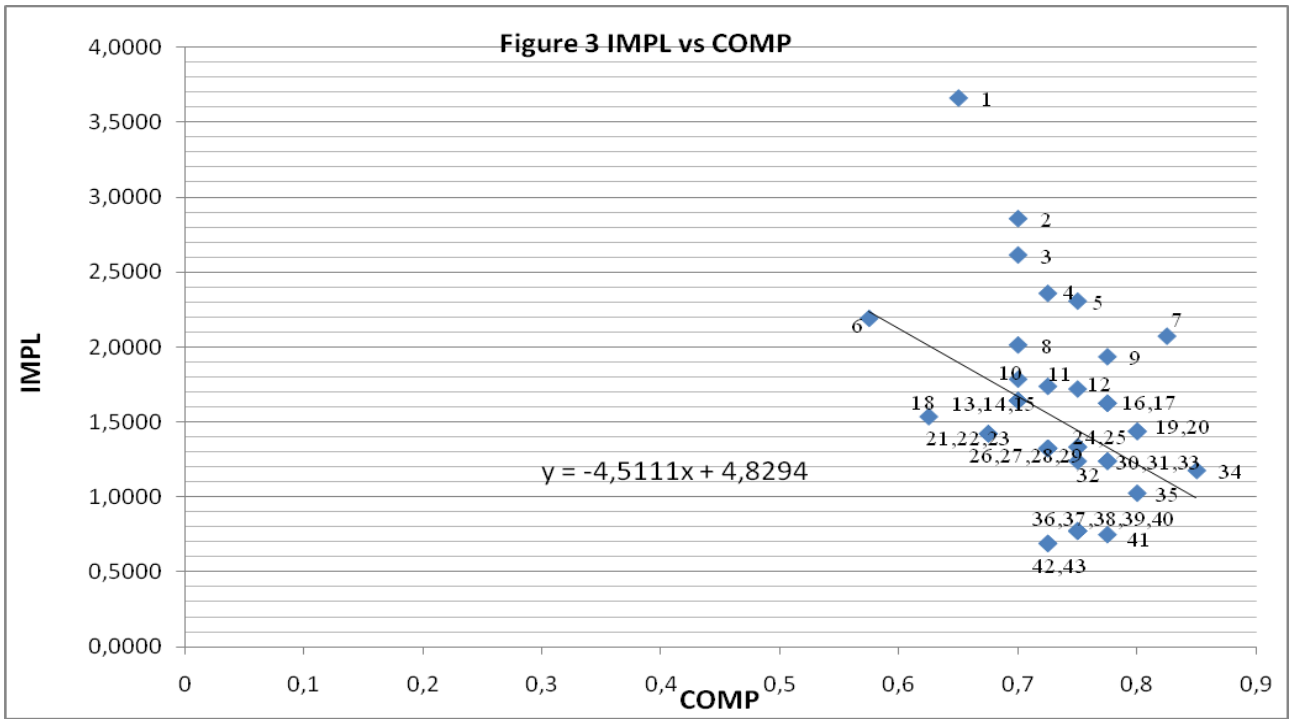


Figure 2 preliminary result of CCFI (with sample correction)





Though CFI and CCFI are highly dependent on STD, they are good critical attribute indicator in comprehensive way. The Managers can allocate resources based on the level or emphasis of criticality (balance with existing resources, new resources). Addition of sample error correction on CFI will give some insight for managers and avoid zero CCFI (If one or both of STD dev is/are zero). The negative correlation from IMPL vs. COMP indicates that the lesser the priority given, the higher critical the attribute and it needs amendments or remedial action to balance the resources. This was applied in communication and implementation of strategies on culturally influenced company (Takala, et.al 2006).

VISUALIZING CRITICALITY AND INTERPRETATION OF THE RESULT

Analysis has been made by using critical factor index that is utilizing expectations, experiences, competitor's performance, gap index, deviations and directions of development. This result is from modified model of CFI that takes in to account the sampling error correction and control limits to clearly see and make balance between high critical factors and lower ones. The managers can get a clue whether they need additional resources or can distribute available fairly from high critical to lower critical (from yellow to red) so as to make green all factors. For instance, assuming we have similar units for different factors e.g. amount of Euros which is allocated for each factor.

Higher critical (HC) = $\sum_{i=1}^{n} U_i - UCL_i$

Low critical (LC) = $\sum_{i=1}^{n} L_i - LCL_i$

Where HC= Higher critical

LC= Lower critical

U_i =Individual factors which are upper than UCL

UCL=Upper control limit from the control chart

$L_{i=}$ Individual factors which are lower than LCL
LCL= lower critical from the control chart
n = number of factors above or lower than UCL or LCL
i = individual factors

Over emphasized: If HC > LC, the company can adjust or balance the resource distribution with the existing facilities/resources under normal situation.

Less emphasized: If HC < LC, the company may face difficulties to adjust or balance the resource distribution with the existing facilities/resources under normal situation.

Fairly emphasized: If HC = LC, at this breakeven point the company may not need balancing or adjusting resources but it need a careful follow up because if one of the attributes/factors disturbed the rest could be affected in both extremes.

In our case, Higher critical (HC) = (2,2212-2,155331)+(2,5332-2,155331)+(3,7539-2,155331) +(2,2212-2,155331)+ (3,9153-2,155331) = 14,6448-10,776655=**3,868145**

Similarly, Lower critical (LC) = (0,585231-0,4471)+(0,585231-0,4471)+(0,585231-0,4448)+(0,585231-0,5073)+(0,585231-0,3305)+(0,585231-0,377)+(0,585231-0,5233) = 4,096617-3,0771=**1,019517**
To sum up, HC>LC so, the company can make resource adjustment/balance by the magnitude of
3,868145-1,019517= **2,848628** gap

CONCLUSION

Several writers indicate service is challenging because of its characteristics like intangibility (cannot be seen and or tasted), inseparability (produced and consumed at the same time), heterogeneity (produced and consumed simultaneously) and perishability (cannot be stored). That is why various technological innovations and its supporting tools and techniques are required on decision making processes. The development of service engineering and service science shows that choosing the clear development targets and creating appropriate indicators on service leads to success. While carrying out service activity assessment using CFI, there should not be too many attributes because the measurement process takes too much time and the target of the development may not come in to existence. In this paper CCFI is used and 6 attributes (red) are found the critical ones (with shortage of resources or under emphasized). On the other hand, 6 attributes were found to be in yellow region that implies the attributes are more than required (over emphasized). So, the manager can have an idea to balance the resources of these attributes by fairly distributing to make all factors in green. The merit of fast, comprehensive and reliable method to identify the critical attributes in order to make managerial decisions at low cost is crucial phenomena and will most probably lead to a further increase of interest of CCFI. However, it still requires further improvement and development and should be tested in various case studies as well. In this paper there are three deliverables, the first one is recognizing the influence of responses' number and avoid zero CFI by adding sample correction error. Secondly, the applications of control chart to determine the three distinct

areas (green, yellow, and red). The third one is application of IMPL vs. COMP that is analysis of emphasized implementation index and evaluation of importance for each attributes.

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AN EVALUATION OF VIRTUAL AND PHYSICAL SHOPPING PROCESS ON CONSUMER PRICE SENSITIVITY: INNOVATIVENESS AS A MODERATOR

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ABSTRACT

The popularity of the Internet facilitate virtual shopping as one convenience shopping choice for consumers. However, consumers would have different evaluation viewpoints on both shopping processes in term of emotions and shopping value. This study designed two scenarios (an virtual shopping website and a trial physical product) and adopted Consciousness-Emotions-Value (CEV) model to examine the effect of consumer emotion and shopping value on price sensitivity. Consumer innovativeness was proposed to have moderating effect on shopping process. Both online- and paper-based questionnaires were used for the field survey and 403 valid questionnaires have collected. The findings revealed that website quality and product usability have a positive effect on consumer emotions; a positive emotion also resulted in higher hedonic and utilitarian value. However, hedonic value had a negative influence on price sensitivity. This indicates that consumers perceiving a higher hedonic value in the shopping process will have a higher willingness to pay more. In managerial implication we suggested what the manufacturer should look into the product design such as to have more friendly and usable functions. For retailer, they should well trained their sales person to serve customer more professionally. Lastly for internet store, they should have a full information to enhance the confidence and trustfulness of the website. 3D panoramic photo should also included to attract consumer attention during the shopping process.

Keywords: Price Sensitivity, Innovativeness, Website Quality, Product Usability

INTRODUCTION

The online shopping market has grown rapidly for the last two decades. According to the Market Intelligence and Consulting Institute (MIC, 2009), almost 90% of the population have experience in shopping online, and the sales have increased 30% in that period. Taiwan online market has a large variety of product choices, including clothes (the largest market), beauty care (second) and consumer electronics product (third). Although online market offers more opportunities for interactive and personalized marketing compared to the

physical market environment. However, consumers are unable to touch and try out the physical products directly in the online environment. Due to insufficient of physical product knowledge, online purchases may be affected by information shortage, perceived risk of trade, perceived price of products, and may, as a result, ultimately affect their willingness of purchasing.

Alba et al. (1997) pointed out that online consumers are able to obtain more information about both price and non-price attributes, and ultimately increase consumer price sensitivity especially when they can obtain more information on price. However, if the quality of the product website is low (such as lacking in information and of poor design, among other faults), price sensitivity may not be affected in the shopping process. That revealed not only products information is important, but website quality may also a driver of consumer price sensitivity. Consumers will have higher price sensitivity when they obtain more information.

Several researches have adopted Consciousness-Emotion-Value (C-E-V) model (Holbrook, 1986) to study the similar area of online or physical shipping environment (Eroglu, Machleit and Davis, 2003; Fiore, Jin, and Kim, 2005). However, there are some areas remained unexplored. Firstly, the "consciousness" is always focused on either website atmosphere, image interactivity features or website social cues when it comes to online shopping (Eroglu et al., 2003; Fiore et al., 2005). And secondly, prior research on product price have mostly focused on online or physical shopping separately, and the product categories include grocery items (Wakefield and Inman, 2003), clothing (Ramirez and Goldsmith, 2009) and digital cameras (Grewal, Munger, Iyer and Levy, 2003).

This study adopted two consciousnesses (website quality and product usability) to examine consumer response toward a high-tech product when they involved in online and physical shopping which remained unexplored in the prior research. By doing so, the study designed two situations - online shopping and physical shopping with a trail physical product to examine consumer price sensitivity in both environments. It is very important to understand the concerns of consumer behavior from different viewpoints that what the elements are to influence their price sensitivity during the shopping process.

In addition, the study proposed consumer characteristic (e.g., innovativeness) have moderating effect on the online shipping process. High innovative or low innovative consumers would have difference behavior in searching and accepting of product information or even have different attitude towards purchasing a high-tech product. As high-tech products (e.g., digital camera) were used as research object, therefore, we try to adopt consumer innovativeness as moderator to examine its moderating effect on the relationship between consciousness and emotions when consumers shop in either an online or physical retail environment.

Digital cameras are one of the top ten products that people buy online (MIC, 2009). Consumers can easily purchase a digital camera from the online shopping websites such as Yahoo and PChome, as well as brick-and-mortar stores such as Carrefour or other electronic stores. Besides, digital camera is one of the most common and popular products in consumer electronic market, almost every consumer own one on hand in average (E-ICP

database, 2008). It has many configurations and designs that include exterior (e.g., color, weight, and shape) and interior (interface performance and ease of use). All these product designs will expect to affect product usability of the user, even the behavioral response. In addition, heavy Internet users are found to be younger, higher educated, and higher income (Porter and Donthu, 2006), which is similar to the characteristics of frequent purchasers of high-tech products (Meuter, Bitner, Ostrom and Brown, 2005).

Based on above discussions, the study conducted two studies to complement the research gaps. Study one established a virtual shopping environment (a website), and provided different level of product information except price for consumers to browse through. Study two provided a physical product (a digital camera) for consumers to try on. The study compared consumer price sensitivity for both online and physical situations by applying CEV model. The constructs included website quality, product usability, consumer characteristics (i.e., innovativeness), emotion (i.e., pleasure, arousal, and dominance), and value (i.e., hedonic and utilitarian) to examine different level of price sensitivity in both online and physical situations. The main objectives of the study are: (1) to propose a research model by using two antecedents (website quality and product usability) to examine their effect on price sensitivity through the path of emotions and shopping value. (2) to test whether consumer innovativeness has a moderating effect on the relationship between website quality, product usability and emotions. And (3) to compare consumer price sensitivity levels between online and physical situations.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Consciousness–Emotion–Value (C–E–V) model

The Consciousness–Emotion–Value (C–E–V) model of the consumption experience is dynamic (Holbrook, 1986), with feedback loops between each component. The first component, *consciousness*, includes cognitions or beliefs about consumer products as well as mental events such as fantasies or imagery during the consumption experience. The second component, e*motion* expands beyond that affect (such as a favorable disposition toward shopping or enjoyment) including subjective feeling states, such as pleasure and excitement. The last component, *value* indicates what the consumer perceives as gains from the consumption experience. This includes hedonic value and aesthetic pleasure from sensory elements during consumption.

The shopping value (hedonic value and utilitarian value) is an issue of influencing consumer shopping behavior. In between product price is also the key to determine whether to purchase from online or brick-and-mortar stores especially high-tech products are always considered as higher price level products. Therefore, this study especially brings price sensitivity into the C-E-V model as a dependant variable and examines consumer price sensitivity in the shopping process with regard to high-tech products. Besides, personal characteristic such as innovativeness could be an element of influencing consumer decision making of purchasing high-tech products. As high innovative consumers are more likely to purchase high-tech products (Meuter et al., 2005); therefore, innovativeness was included in the C-E-V model as a moderator between the relationship of consciousness and emotions.

In line with a C–E–V approach, this study is designed to test the relationship between consciousness (website quality and product usability), emotion, value (shopping value) and personal characteristic (innovativeness) to examine whether different consumers who shop on the Internet or in brick-and-mortar stores can be stimulated by website quality and product usability consequently will have different emotions and shopping value that affect their product price sensitivity.

Consciousness - Website Quality

Research on website quality can be classified into two different research streams. The first stream is identifying the attributes that contribute to website quality and has resulted in the development and testing of instruments to measure website quality. The dimensions are including website appearance, content or information, and the quality of online technical websites, including such attributes as response time or interaction (Aladwani and Palvia, 2002). His results revealed that web quality could be measured by web appearance, web content (divided into special content, and content quality), and technical adequacy. *Web appearance* refers to website organization, proper use of fonts, proper use of colors, proper use of graphics, and graphics-text balance, among others. *Web content* includes special content that consumer can find contact detail about product information as well as consumer policy; and content quality refers to overall information about the product, such as its usefulness, completeness, and configuration, and etc.. *Technical adequacy* refers to security, availability, reliability, personalization or customization, interactivity, and ease of access, and etc..

The second stream is an examination of the website quality effect on consumer perceptions and intentions, which is not the focusing area of this study. Accordingly, this study adopts the four dimensions that stated by Aladwani and Palvia (2002) and defines it as users' evaluations of website features meeting their needs and reflects four degrees: web appearance, special content, content quality and technological adequacy of a website when they searching a high-tech product.

Consciousness - Product Usability

Consumer electronic products such as mobile phone, digital camera, and etc. have integrated various technologies into different areas such as video, audio, computer software and hardware. However, multifunctional product doesn't mean it has higher level of usefulness or usability. It can be more complicated and hard to use. This trend makes the usability become one of the most important design issues. Based on the concept of human-computer interaction (HCI), usability was originally defined as the degree of ease of use (by subjective assessment) and effectiveness of use (by objective performance) within the specified range of users, tasks, tools, and environment (Shackel, 1984).

Han, Yun, Kwahk, and Hong (2001) define product usability more specifically as the degree of satisfying the users in terms of both the performance and the image and the impressions felt. There are two dimensions have been proposed: performance, and image/impression. Performance can be classified into three categories: *perception/ cognition* consists of examining how well the users perceive and interpret the interface of a product;

learning/memorization explains how fast the users get used to the product and how well they remember its functions; and *control/action* represents the users' control activity and its results. Image/ impression also can be classified into three categories: *basic sense* includes the primitive image and impressions stemming from the product; *description of image* explains the image and impressions of a product that users will describe based on their experience; and *evaluative feeling/attitude* explains the attitude or judgmental feelings as a whole about the product.

Accordingly, the study defines product usability as the satisfaction level of high-tech product users with regard to both the performance and the image/impressions they feel. This study expects that these two factors will affect consumer emotions during the shopping process.

Emotions - Pleasure, Arousal, and Dominance

Consumer emotional contribution is an essential element for decision making when doing shopping (Zaltman, 2003). Emotion can be considered as a mental readiness that arises from appraisals of events or of one's thoughts (Bagozzi, Gopinath and Nyer, 1999). According to the environmental psychologist Mehrabian and Russell (1974), all emotional responses to physical and social environments can be captured with three dimensions: pleasure, arousal, and dominance (PAD). These three dimensions can adequately represent all of the diverse human emotional reactions to environment and measure one's feelings that, in turn, influence behavior.

Pleasure refers to the degree to which a person experiences an enjoyable reaction to some stimulus in the shopping environment; it consists of happiness, enjoyment, and satisfaction. Pleasure is found to have positive relationship with consumer behavior as they will spend extra time on shopping and consumption as well as on satisfaction (Liu and Arnett, 2002). *Arousal* is defined as a combination of mental alertness and physical activity which one feels stimulated, excited, or alert in the shopping environment. More specifically, arousal demonstrated to increase shoppers' intentions to remain and to spend money in conventional retail environments (Foxall and Greenley, 1998). *Dominance* refers to the extent to which the individual feels restricted/ unrestricted or in controlled or uncontrolled the shopping environment. Virtual online shopping environments are more technically complicated and information-intensive than traditional ones. It influences the extent to which online users perceive themselves to be able to dominate their interaction with the environments they encounter. Dominance specified in the environmental psychology model, has been also found to have significant impact on users' behavioral decision.

Shopping Value - Hedonic Value and Utilitarian Value

Shopping value is an evaluation subject after one has interaction experience with the activities, and it is a key outcome in a general model of consumption experiences (Babin, Darden and Griffin, 1994). Perceived value is defined as the consumer assessment of what is received relative to that which is given (Zeithaml, 1988), and it is recognized as an important marketing construct due to its relationship with quality, customer satisfaction and loyalty (McDougall and Levesque, 2000). As a starting point, consumer behavior researchers

recognize two pervading, dichotomous motivations for shopping: hedonic and utilitarian (Hirschman and Holbrook, 1982).

Hedonic value is an outcome related to spontaneous responses that are more subjective and personal (Babin et al., 1994). Hedonic values, such as entertainment, exploration, and self-expression (Ailawadi, Neslin and Gedenk, 2001), derive more from fun and enjoyment than from task completion and are non-instrumental, experiential, and affective (Chaudhuri and Holbrook, 2001). *Utilitarian value* results from the conscious pursuit of an intended consequence (Babin et al., 1994). It is primarily instrumental, functional, and cognitive and represents customer value as the means to an end (Chandon et al., 2000).

In the consumer shopping process, the hedonic motive relates to experiential shopping where the fun, entertainment and escapism of the shopping process may be paramount for acquiring products. Consumers often shop for an appreciation of the experience rather than simply for task completion (Childers, Carr, Peck and Carson, 2001). In contrast, the utilitarian motive underscores task-specific, rational and deliberate product acquisitions where shopping is perceived to be work or a necessity (Babin et al., 1994) and the task-specific use of shopping, such as purchase deliberation (considering the product, service, and price features before actual purchase) (Hoffman and Novak, 1996). Though usually prompted by one overriding motive, a shopping incident may provide both utilitarian and hedonic value (Babin et al., 1994).

This study examines consumer's shopping value in the high-tech product shopping process for both internet and brick-and-mortar stores. We define hedonic value as consumer experience fun, entertainment and escapism of the shopping process. As the study are not focusing on the price feature, we therefore define it as task completion, convenience and deliberate product acquisitions, except price, where shopping is perceived to be work or a necessity.

Innovativeness as a Moderator

Rogers (1995) defined innovativeness as the early adopter of new technology. Cotte, and Wood (2004) defined innovativeness as the willingness of embrace change, try, and buy new products more often and quickly than others. Personal innovativeness in some individuals means that they are willing to take risks. In innovation diffusion research, highly innovative individuals are showed to be active seekers of new ideas. They are able to cope with high levels of uncertainty and develop more positive intentions to accept. (Lu, Liu, Yu and Wang, 2008).

An alternate concept of innovativeness that proposed by Goldsmith and Hofacker (1991) as domain specific innovativeness (DSI). It has been found to have associated with wide range of innovation adoption. DSI aims to explicate the narrow facets of human behavior within a person's special interest domain (Midgley and Dowling, 1993). It captures the individual's predisposition toward the product class, and refers to the tendency to acquire new products or related information within a specific domain (Goldsmith and Hofacker, 1991). Of pertinence here, Goldsmith (2001), and Blake, Neuendorf and Valdiserri (2003) applied the DSI measure to online shopping. In this study, we defined innovativeness as the relative

willingness of a person to search, try or buy a new high-tech product regardless of the virtual or physical shopping environment.

High-tech products have higher uncertainty and complexity; consumers will need to put more effort and time to familiarize with it. When consumers venture into the adoption of new products, they face a dilemma between desirable and undesirable consequences of the product adoption and hence face a risky decision (Hirunyawipada and Paswan, 2006). Although several studies (Conchar, Zinkhan, Peters and Olavarrieta, 2004) have suggested that perceived risk may have negative influence against the decision to adopt new products, actual adoption is a function of consumer receptivity toward the specific product, and the perception of risk may not have much to do with actual adoption. However, it may lead to consumers seeking more information in order to ascertain the level of risk, mitigate the perception of risk, or manage the perceived risk (Hirunyawipada and Paswan, 2006). Therefore, consumer innovativeness serves an important role in the adoption of a high-tech product and determines whether they will accept the risks involved, even if this affects the consumer value toward the product.

Price Sensitivity

Price sensitive consumers seek low prices and are less likely to buy when prices rise. Contrary, less price sensitive consumers are willing to pay higher prices for the same goods than are price sensitive consumers and are more willing to buy if prices go up (Foxall and James, 2003). The definition of price sensitivity basically can be classified into two different categories. Firstly, Wakefield and Inman (2003) defined price sensitivity as individuals perceive and respond to the changes or differences in prices for products or services. And secondly, referring to the weight attached to price in a consumer valuation of a product's overall attractiveness or utility (Erdem et al., 2002). This study focuses on the effects of price sensitivity and does not examine the price changes. Therefore, we define it as the weight attached to price in a consumer valuation of a high-tech product's overall attractiveness or utility in the shopping process, which is similar to the second definition.

Price sensitivity is one of the behavioral intention factors that affect consumers' behavior. Not many studies have specialized in research on the effect of price sensitivity, linking consumer characteristics or shopping environments, especially in online websites, together with price sensitivity. Degeratu, Rangaswamy and Wu (2000) found that consumers who shop online have more price sensitivity than they do in physical environments and will compare prices carefully on websites. Digital camera is one of the high-tech products that upgrade rapidly. Consumers may need more information to compare each version, including the product configurations as well as prices. But not all online consumers are willing to purchase it online as they haven't seen the physical product and have no chance to try it. The study intends to examine the website factors (the website quality) and the physical product factors (the product usability) that may influence consumer price sensitivity while they are shopping online or brick-and-mortar stores.

Website Quality, Product Usability and Emotions

The first stimulus variable: website quality. Mehrabian and Russell (1974) classical affect model has supported the notion that stimuli in the physical environment influence people's emotions (such as arousal and pleasure responses) in brick-and-mortar stores (Baker, Levy and Grewal, 1992), as well as internet stores (Eroglu et al., 2003). Although in many instances, the dominance dimension is not included, probably due to Russell's (1979) recommendation that pleasure and arousal alone can adequately represent the range of emotions exhibited in response to environmental stimuli. In the online retail context, it is possible that shoppers choose online rather than traditional retail outlets for the increased control over the shopping situation. Conversely, online shoppers may feel a decreased level of dominance in situations where download times are slow, when there is no way to contact the retailer for more information, when the site is difficult to navigate, or when links are missing or inactive.

Recently, research has cited many examples showing the relationship of website quality to emotions. For instance, Fiore et al. (2005) found the image interactivity feature of shopping websites to be a stimulating experience that was positively associated with the level of emotional arousal and pleasure. Ethier et al., (2006) showed that website quality had a positive impact on the cognitive appraisal of a situational state, which in turn influenced emotions experienced by consumers while shopping online. When consumers have a more positive evaluation of an online shopping experience, they experience a higher level of the intensity of emotions such as enjoyment, joy and pride. However, the more negative the evaluation, the higher the intensity of dislike and frustration. Hence, the first hypothesis is proposed:

Hypothesis 1: Website quality can positively affect the emotions (pleasure, arousal, and dominance) of high-tech product shoppers.

Another stimulus variable is product usability. Depending on the level of expectancy confirmation or disconfirmation on important benefit dimensions, a product may evoke positive, negative, or a mixed set of emotions (Bagozzi et al., 1999; Chaudhuri, 2006). Many researches emphasize the effects of product performance and design (i.e., product form, product appearance, product usability) on consumer response. Such as, Bloch (1995) pointed out that product design can affect consumer cognitive and affective responses, include positive and negative aesthetic responses. Besides, Garber (1995), and Crilly, Moultrie and Clarkson (2004) argued that product appearance, product categorization, product form (e.g., colors, texture, materials), and visual perceptions can affect consumer cognitive and affective responses effectively.

In more recently, the Pre-purchase Affect Model (PAM) (Seva, Duh and Helander, 2007), a conceptual model of product emotion that includes product attributes, purchase criteria, pre-purchase affect and purchase intention was proposed. This model connects product attribute with pre-purchase and accepts the positive relationship caused by purchase criteria as the moderator. Seva et al. (2007) suggested that the product attributes of a mobile phone positively affect pre-purchase emotions. For example, the width of the phone's body significantly affected feelings of contentment and encouragement to buy. This

study expects product usability (performance and image/impressions) would have positive effect on consumer emotions (pleasure, arousal, dominance) toward the physical shopping process. Hence, the second hypothesis is proposed:

Hypothesis 2: Product usability can positively affect the emotions (Arousal, pleasure and dominance) of high-tech product shoppers.

Moderating Effect – Innovativeness

Rogers (1995) noted that people are more innovative when they feel comfortable with technology. When consumers feel anxiety, fear, and apprehension in using technology tools, they will avoid to change, buy, and use a new one (Meuter et al., 2005). These consumers therefore possessed a negative attitude towards technological products. Researchers have noted that adoption of online shopping methods is a functional behavior not only of attitudes, needs, and experiences, but also of personal characteristics such as innovativeness (Robinson, 2005). More specifically, consumers who have higher innovativeness are more likely to seek multiple sources of information and new experiences that stimulate their senses as they form their perceptions toward a technology (Agarwal and Prasad, 1998).

This study proposes that innovativeness will have moderating effect on the relationship between consumer perception regarding shopping website quality, product usability, and emotions. Therefore we infer that high innovative consumers are easy to fall into the enjoyment of high-tech product shopping environment (such as surfing on the high-tech product website). Besides, we also believe that when the consumers once use the new product, they will be more likely trying it. That will result in the consumer perceiving the stimulus and experiencing a higher degree of emotions than the consumers with low innovativeness. Therefore, the study infers highly innovative consumer would perceive website quality and product usability to have more intense emotions when the website or the product designed fantastically. The study proposes that the high innovativeness of consumer characteristic has moderating effect on the relationship between product usability and emotions. The higher the consumer innovativeness is, the stronger relationships will be between website quality, product usability and emotions.

Therefore, this study examines “high-tech product innovativeness” as the moderator between website quality, product usability and emotions. Hence, the third and fourth hypotheses are proposed:

Hypothesis 3: Innovativeness has moderating effect on the relationship between website quality and emotions of high-tech product shopping process.

Hypothesis 4: Innovativeness has moderating effect on the relationship between product usability and emotions of high-tech product shopping process.

Emotions and Shopping Value

Increased arousal, heightened involvement, perceived freedom, fantasy fulfillment, and escapism all may indicate a hedonically valuable shopping experience (Hirschman, 1983).

Pleasure should increase consumer hedonic value through fun or entertainment and/or their utilitarian value by facilitating of completing product acquisition (Isen, 1987). Hedonic values are an expression pleasure and anticipation; while utilitarian benefits are related to task completion and are not necessarily pleasurable or anticipated, but instead merely indicate tolerance or sometimes apprehension.

Babin et al. (1994) found that the emotions of shopping process are positively correlated with both hedonic value and utilitarian value. They found not all consumer behavior is directed toward satisfying some functional, physical, or economic need. In addition, the validity of hedonic and utilitarian shopping value is supported by its correspondence with a number of theoretically related individual difference characteristics, behavioral measures, and situational factors. Wang et al. (2007) investigated how the social cues inherent in avatars influence affects and shopping value. They found social cues induce perceptions of website socialness, leading to increased pleasure and arousal, both of which positively influence flow, hedonic and utilitarian value, and patronage intentions. Thus, this study predicts the following hypotheses:

Hypothesis 5a & 6a: In the online shopping situation, shopper emotions (arousal, pleasure and dominance)can positively affect their hedonic shopping value (H5a) and utilitarian shopping value (H6a).

Hypothesis 5b & 6b: In the physical shopping situation, shopper emotions (arousal, pleasure and dominance)can positively affect their hedonic shopping value (H5b) and utilitarian shopping value (H6b).

Shopping Value and Price Sensitivity

Interestingly, the price elasticity of detergent is quite a bit larger than the food and toiletries, which are relatively more hedonic categories (Tellis, 1988). The differences in elasticity for these products may also be influenced by varying promotional frequencies of functional and hedonic goods. Wakefield and Inman (2003) suggested that consumers are lower prices sensitive when making a hedonic purchase. Because hedonic products always provide hedonic value such as entertainment and enjoyment, we propose that the hedonic value for a consumer will be higher as a result of experiencing an online shopping website and that price sensitivity will result to be lower.

When the product performance and function fit the user needs, we then consider utilitarian value to have a negative relationship with price sensitivity; however, the negative degree may be lesser than that of hedonic value. Bigné and Andreu (2004) pointed out that when consumers are experiencing greater pleasure and arousal that will show an increasing level of satisfaction as well as more favorable behavioral intentions, meaning loyalty and willingness to pay more. This reveals when consumers perceive the service or product have great quality, they experience positive emotions toward the shopping process and have more willingness to pay more. Hence, this study suggests that both hedonic and utilitarian values will influence price sensitivity negatively.

Hypothesis 7a & 8a: In the online shopping situation, shopper hedonic shopping value (H7a) and utilitarian shopping value (H8a) have negative relationship with their price sensitivity of purchasing high-tech products.

Hypothesis 7b & 8b: In the physical shopping situation, shopper hedonic shopping value (H7a) and utilitarian shopping value (H8a) have negative relationship with their price sensitivity of purchasing high-tech products.

RESEARCH FRAMEWORK AND METHODOLOGY

Research Framework

The study adopted Consciousness-Emotions-Value (C-E-V) model to examine whether the process of online and physical shopping such as consciousness, emotions, and value would have effect on consumer price sensitivity. We designed two stimuli (online website and physical trial) to carry out the study as consciousness; the elements included website quality (Study A) and product usability (Study B). The conceptual framework of the two studies was showed in Figure 1.

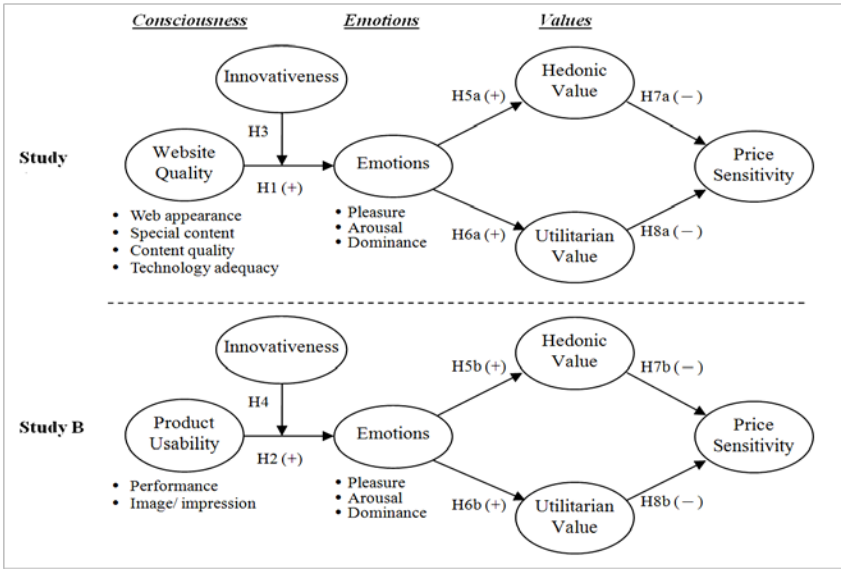

Figure 1: Conceptual Framework of Study A (online) & Study B (physical).

Research Design

The study adopted previous research measurement to measure all research constructs, and modified them based on the study scenario. Participants who had experience in online and physical shopping were legitimate to respond to the study. The participants were asked by both online- or paper-based questionnaire to express their opinions of shopping experiences. All measurement used seven point Likert scale, except for the construct of price sensitivity. There were eight items to measure this construct, the first five items were seven Likert scale, but the last three were asking the price range, such as “how much you willing to pay for the digital camera?” which adopted from Grewal et al. (2003).

Stimuli Selection

First of all, two different types of digital cameras were chosen based on the E-ICP data-base (2008), which were the top ten most popular brands in the electronic market. We named the two products as product "A" and "B". For Study A, the website quality stimulus, three different levels of shopping website (including information, content, and appearance) were designed to distinguish the consideration of C-E-V line more efficiently, and the product price was not showed. Participants were randomly select a questionnaire and linkage for surfing and answering the whole questionnaire except for the product usability section.

For Study B, the product usability stimulus, each participants were assigned one of the products randomly and asked to try on the functions such as taking picture, adjusting the monitor light, photoflash or night scenes photo and etc.. The brand names were covered to avoid any influenced by the brand perception. It is believed that respondents could experience the digital camera interface on trail, and evaluate the product design such as the color, weight, shape, and comfort, which were related to the product usability performance, and image/ impression dimension. Participants were then asked for answering the whole questionnaire except for the website quality section.

Pilot Test

Before the formal questionnaire was formed, a pilot test was conducted to ensure the measurement reliability. There were 33 questionnaires have collected for Study A, the website situation, and 30 for Study B, the product situation. All questionnaires were valid except for two from the Study A. The results of pilot test showed all item-to-total and Cronbach's alpha were close to or above the thresholds (0.5 and 0.7) except for the item 4 and 5 in website quality dimension – technical adequacy scale, and the item 4 in the product usability dimension – image/ impression scale. Therefore, these three items were deleted from the formal pool of questionnaire. In order to improve the items' reliability, we also modified those items that lower but close to the threshold.

RESULTS OF DATA ANALYSES

The study used online-based questionnaire for Study A and paper-based for Study B. As results, Study A had collected 312 responses and Study B had 161 responses. There were 59 invalid for Study A and 11 for Study B. The invalid respondents were mostly categorized as such due to incomplete questionnaires or answering the reversed items in the same direction.

The demographic analysis revealed that the gender proportion was almost equal (Males=51.4%, Females=48.6%) and that majority of age range was from 20-29 (81.4%). Most of respondents had earned a bachelor's degree or higher (93.3%). Due to the fact that the majority of the respondents were students (53.8% student, 42.8% working), their incomes were mostly below US$600 (72.5%).

Confirmatory Factor Analyses (CFA)

The study used AMOS 5.0 and adopted two-step approach for the formal data analyses. Before proceeding to test the CFA, we firstly check out the items reliability by using the thresholds of item-to-total (0.5) and Cronbach's alpha (0.7). As results, five items were deleted due to low item-to-total, and all alpha value were above the threshold.

Under the CFA assessment, we used chi-square (χ^2/df = < 3) to examine the model fit. Due to the significant level of chi-square is affected by increasing of respondents; therefore, more indices are used. Table 1 exhibited the criteria and the results of model fit.

Table 1: Measurement Model Fit for Confirmatory Factor Analyses.

Model Fit Indices	Study A	Study B	Recommended Value (Hair et al., 2006)
Chi-square/ *df*	2.058 (*p*=.000)	1.862 (*p*=.000)	≤ 3
Goodness of Fit Index (GFI)	.854	.810	> .80
Adjusted Goodness of Fit Index (AGFI)	.816	.793	> .80
Comparative Fit Index (CFI)	.954	.925	> .90
RMSEA	.065	.076	< .08

The CFA results including standardize factor loading magnitude, and convergent validity analysis: average variance extracted (AVE) and composite reliability (CR). All factor loadings were significant (t > 3.84) and above the threshold of 0.5 (Hair et al., 2006). We assessed AVE and CR value separately by the Study A and B as showed in Table 2. The results showed all AVE and CR value in both studies were above the thresholds of 0.5 (Hair et al., 2006), and 0.7 (Fornell and Larcker, 1981) respectively, except for the construct of product usability of Study 2. The study found that the respondents were mostly answered different directions for the questions of the product usability's dimensions (performance and image/impression). This might be the reason why it had lower AVE and CR value.

Table 2: Convergent Validity and Reliability Analysis.

Observed Variables (Study A and Study B , *n*=403)	α	Study A		Study B	
		AVE	CR	AVE	CR
Website Quality (Study A, *n*=253)	.956	.705	.904	-	-
Product Usability (Study B, *n*=150)	.938	-	-	.433	.604
Emotions	.915	.552	.774	.629	.835
Hedonic Value	.920	.838	.935	.682	.867
Utilitarian Value	.929	.833	.935	.627	.868
Innovativeness	.891	.536	.887	.575	.904
Price Sensitivity	.902	.776	.911	.749	.898

Discriminant validity, the study calculated the AVE for all pairs of constructs and compared the square root value to the correlation between the two constructs of interest (Fornell and Larcker, 1981). In order to demonstrate the original value of correlation estimation, the square root of the AVE was used as a diagonal value to contrast with the original value of the correlation estimation. As the results all correlation estimation for both studies was slightly higher or lower than the diagonal value, except for the product usability of Study B

as showed in Table 3. That revealed product usability had correlation with other constructs. Due to the nomological reasons that the concepts of product usability was adopted from Han et al. (2001), and several prior studies had applied it to examine consumer electronic products such as MP3/CD players (Eraslan, 2009), mobile phones (Yun et al., 2003) and screening products (Han and Yang, 2004). Therefore, this construct should be suitable for our study. Hence, we remained it for further analyses.

Table 3: Discriminant Validity Analysis.

Construct	Inter-Construct Correlation					
Study A	WQ	EM	HV	UV	PS	INN
Website Quality	**.839**					
Emotions	.834	**.743**				
Hedonic Value	.808	.754	**.910**			
Utilitarian Value	.836	.773	.903	**.913**		
Price Sensitivity	-.585	-.683	-.718	-.680	**.880**	
Innovativeness	.036	.152	.133	.069	-.223	**.732**
Study B	PU	EM	HV	UV	PS	INN
Product Usability	**.658**					
Emotions	.982	**.793**				
Hedonic Value	.943	.744	**.826**			
Utilitarian Value	.953	.728	.725	**.792**		
Price Sensitivity	-.880	-.642	-.695	-.597	**.866**	
Innovativeness	.556	.370	.419	.408	-.481	**.758**

Notes: Diagonal value was square root of AVE value.

Structural Equation Model (SEM) Analysis

The study used maximum-likelihood estimation to assessed SEM analysis. All coefficients were standardizing. A homogeneity of variance test had been conducted; the results revealed they have no significant different between the two groups of respondents. It revealed the two groups of data were appropriate for SEM analysis.

The same model fit indices and criteria were used in the full model analysis, such as GFI, AGFI, CFI and the RMSEA. The model fit results and the path analysis with standardize coefficients of Study A and B were showed in Figure 2 and 3. It revealed both models had good fit as all indices were above the requirement values. Besides, there were five paths for the main effect in each study. It revealed all hypotheses testing were significant and supported statistically except for the hypothesis 8a, and 8b which showed insignificant. Furthermore, the path of H2, product usability towards emotions demonstrated a beta value which larger than 1 (β = 1.094). Since in the earlier discriminant analysis was also not fulfilling; therefore, we intended to modify the model of Study 2 for further analysis.

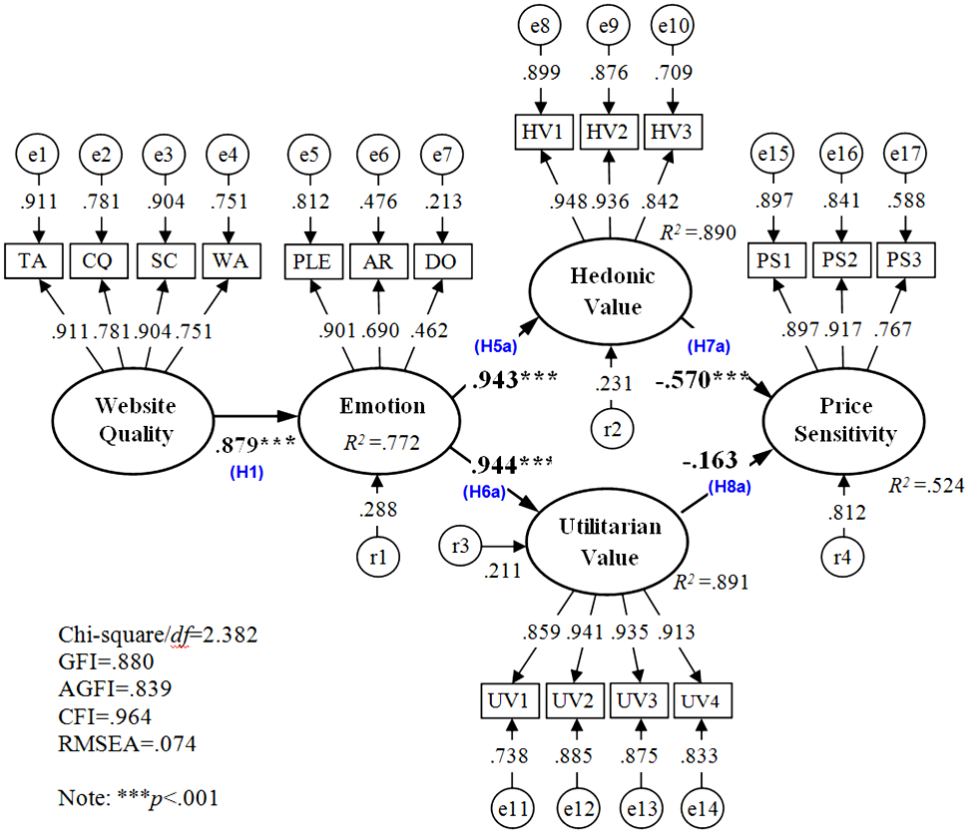

Figure 2: Results of Structural Equation Modeling- Study A.

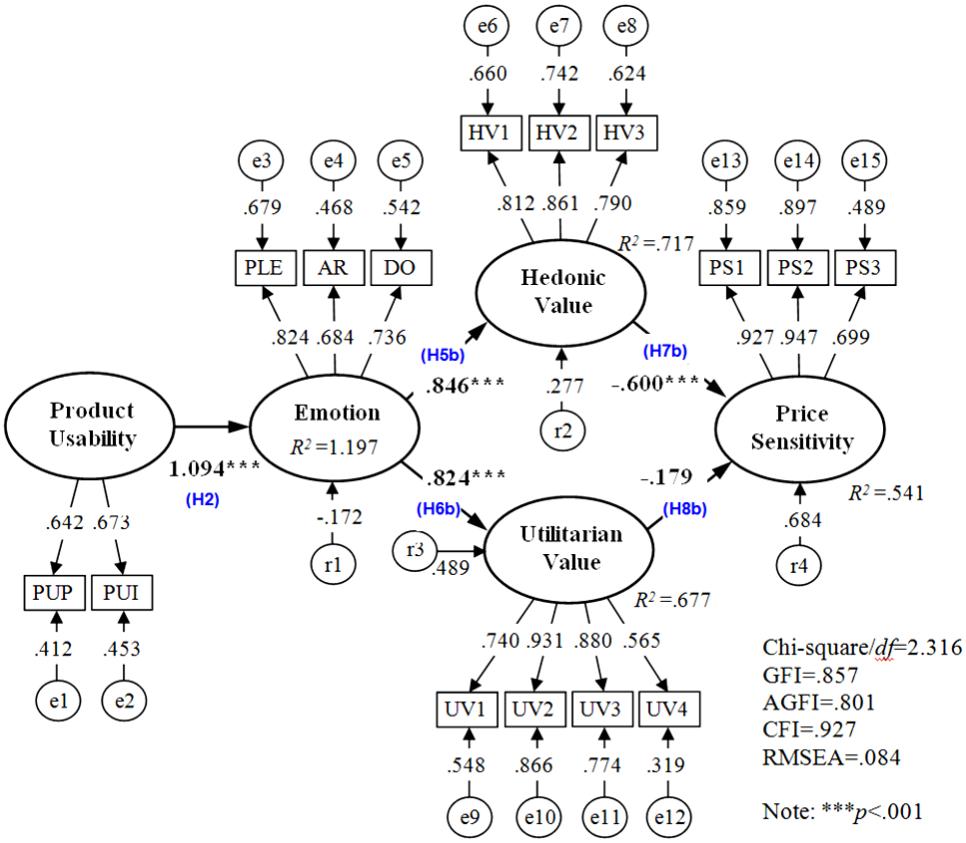

Figure 3: Results of Structural Equation Modeling- Study B.

As mentioned earlier, the respondents mostly answered the questions of the two dimensions of product usability (performance and image/ impression) in different directions. Therefore, we intended to separate the two dimensions into two independent variables to test the model. The hypothesis was named as 'H2p' for performance and 'H2i for image impression. The path diagram and model fit results of the modification model was showed in Figure 4. They had a better results for the hypothesis H2p (β=.472, p=.000) and H2i (β=.532; p=.000). It could explain that the product image/ impression would have higher effect on consumer emotion during the shopping process.

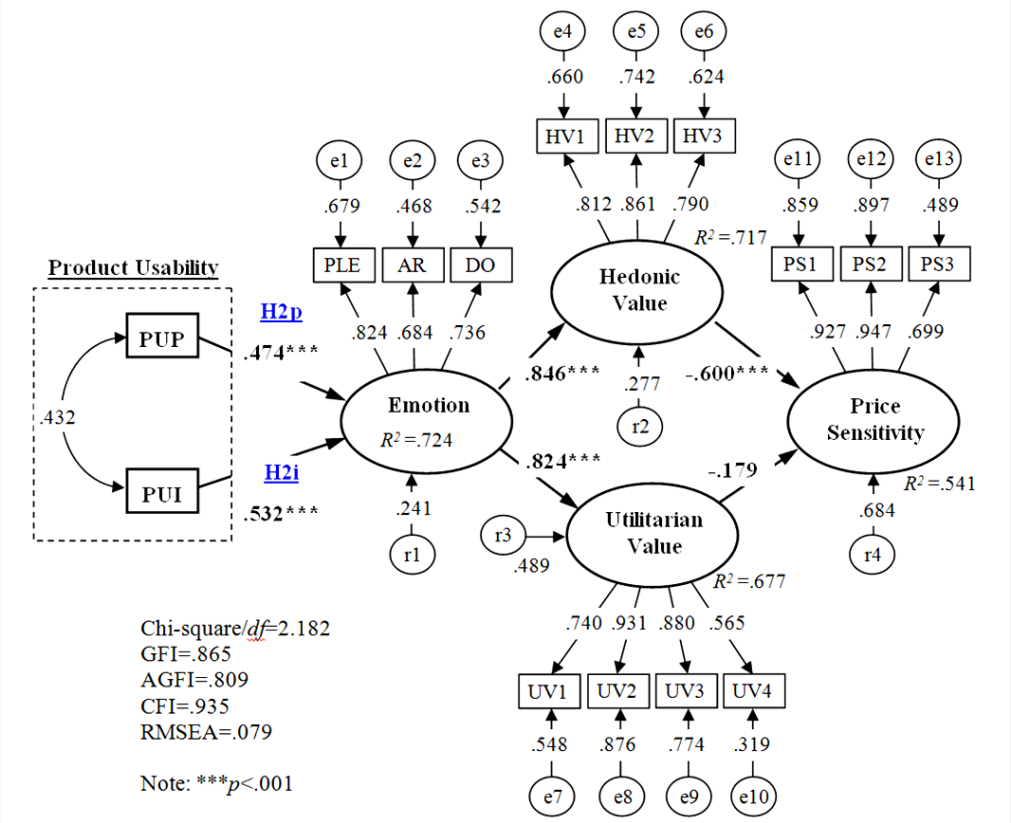

Figure 4: Path Diagram of the Modification Model (Study B).

Hierarchical Regression Analysis

The study used hierarchical regression analysis to test the moderating effect of innovativeness on the relationship between website quality, product usability and emotions. They were three models, model 1 and 2 comprised the independent variables of website quality, product usability and innovativeness; and the model 3 testing the interaction effects. Table 4 showed the results of both Study A and B. All direct effects were statistically significant except for the innovativeness on emotions in Study B. The interaction effects (model 3) for both studies also showed insignificant in the study. It revealed that innovativeness had no moderating effect on the relationship either between website quality nor product usability and emotions.

Table 4: Hierarchical Regression Analysis for Study A and B.

Predictor variable: WQ = Website Quality PU = Product Usability	Dependent Variable: Emotions					
	Model 1		Model 2		Model 3	
	Study A	Study B	Study A	Study B	Study A	Study B
Direct Effects						
Website Quality	.516***		.510***		.505***	
Product Usability		.877***		.885***		.885***
Innovativeness			.151**	-.024	.155**	-.021
Interactions						
WQ x Innovativeness					.031	
PU x Innovativeness						-.015
R^2	.495	.650	.515	.651	.516	.651
Adjusted R^2	.478	.630	.497	.628	.496	.626
F	29.854***	32.751***	28.619***	28.960***	25.844***	25.903***
ΔR^2	.479	.523	.020	.000	.002	.000
ΔF	231.130***	210.652***	9.964**	.173	.936	.086

Notes: ** p<.01 ***p<.001; all coefficients are standardized.

Comparison of Two Studies

The study used *t*-test to compare the mean values and examine the differentiation between two studies of all constructs. The results showed in Table 5. There were four constructs: emotions, hedonic and utilitarian value, as well as price sensitivity. As mentioned earlier, price sensitivity had two parts of items (part 1: seven points and part 2: price ranking); therefore, separate it into two. The results showed that emotions and the part one of price sensitivity items (PS1, PS2, and PS3) had no statistical difference between two study. However, hedonic and utilitarian value and the part 2 of price sensitivity items (PS6, PS7, and PS8) showed statistical difference between Study A and B. The mean values indicated that consumers shop with the physical products have significantly higher hedonic and utilitarian shopping value than shopping online. However, the price sensitivity of online shoppers was significant higher than the physical product shoppers. It revealed that consumers who shop with physical products will have lower price sensitivity, and willing to pay more.

Table 5: *t*-Test for Comparison of Two Studies.

Dependent Variable	Studies	*N*	*M*	*SD*	*t*-value
Emotions	A	253	4.285	0.922	-.464
	B	150	4.329	0.924	
Hedonic Value	A	253	3.909	1.410	-2.132*
	B	150	4.160	0.948	
Utilitarian Value	A	253	4.317	1.427	-3.041**
	B	150	4.692	1.034	
Price sensitivity (PS1, PS2, PS3)	A	253	3.481	1.318	-.640
	B	150	3.564	1.177	
Price sensitivity (PS6, PS7, PS8)	A	253	4.520	1.218	2.057*
	B	150	4.270	1.195	

Notes: *p<.05 **p<.01

DISCUSSIONS AND RECOMMENDATIONS

Discussions

Consciousness, Emotions and Shopping Value

Similar to the previous researches, the shopping consciousness such as website quality and product usability would have positive effect on the shopper emotions (Eroglu et al., 2003; Fiore et al., 2005). When consumers browsed through the shopping websites, the quality of the website, such as full of information (i.e., content quality), technical adequacy, and the appearance of the website, including colors, layout, and etc., would affect their shopping emotions. Fiore et al. (2005) also pointed out that the more positive the evaluation of online shopping experience, the higher the intensity of the emotions of enjoyment, joy and pride; oppositely, the higher the intensity of dislike and frustration would be.

From the view point of physical products, when consumers have an opportunity to physically try and hold the product would affect their shopping emotions. Especially in the Y generation, if the physical product possessed comprehensive functions (i.e., product performance), and modern design (i.e., image/ impression), it would be more favorable for these people to have one (Seva et al., 2007). Seva et al. also pointed out that the product attribute of a mobile phone positively affected consumer pre-purchase emotions.

Furthermore, the study revealed consumer emotions toward the website and the physical product have positive effect on their hedonic and utilitarian shopping value. In the shopping process, when consumers possess positive emotions (e.g., happy, enjoyment, pride, and etc.) , they would perceived the shopping activities as higher hedonic and utilitarian value no matter they shopping online or with physical trial products. It is rational that when one has positive emotions towards an activity, they will think it is worth for doing so because it brings them happy and in fact, they enjoy doing it. Therefore, we can conclude that positive emotions would have positive relationship with hedonic and utilitarian shopping value.

Shopping Value and Price Sensitivity

The study expects consumer shopping values (hedonic and utilitarian) would have negative relationship with price sensitivity. However, the study only found a supporting result on the hedonic shopping value; utilitarian value was not supported. Tellis (1988) pointed out that price elasticity is more negative for all other product categories other than for pharmaceutical products. Consumers would be more concern the product safety, effectiveness, and timing rather than the price. This indicates that consumers who are more rational, they will be more concerned on the product usability rather than the price. Based on some respondents' comments, they mostly search high-tech products on the internet for more information including price and configurations, but will visit the retailer to try the physical product performance. Because they believe it always have some differences between the internet and the physical one about the product image.

Besides, Wakefield and Inman (2003) pointed out that consumers are lower price sensitive when making a hedonic purchase. When the consumers perceived the shopping process has

hedonic value, no matter shopping online or with a trail product, they may have lower price sensitivity and higher willingness to pay more. Thus, we can conclude that perceptual consumers may have lower price sensitivity.

Moderating Effect of Innovativeness

The moderating effect of innovativeness was not supported by both studies. We think the digital camera that we used were not innovative enough (not the latest version). The products may not aroused the respondents feelings of innovativeness when they answering the questionnaire. This may be the reason why the moderating effects were not supported.

However, the some respondents comment that they willing to pay most for the new technology product such as iphone or ipad. They are just so excited to try new technology, therefore, price is not to most concern for them. Accordingly, we can posit that innovative people will have lower price sensitivity, and they are likely to pay more for the new technology products. Roehrich (2004) argued that innovativeness consumers were willing to change, try, and buy new products more often and quickly than others. As well as Goldsmith et al. (2005), they urged innovative consumers have negative correlation with price sensitivity.

Comparison of Study A and B

Based on the comparison results, consumers who shop with a trial product showed significant and higher mean score on hedonic and utilitarian value then the online shoppers. The results indicated that consumers will feel more realistic when they shop with a trial product. Hedonic value will be enhanced as they may enjoy in playing with it. Simultaneously, when the product functions can meet for their needs, which will enhance their utilitarian value.

Price sensitivity was significant when asking the respondents how much they would have willingness to pay for the product (item PS6, PS7, and PS8). These items are more direct and can reflect the ideal price of the product more accurately. The mean score of online shopping have higher price sensitivity. As mentions earlier, consumers can obtain products information from the Internet in all areas. They would also compare the internet price with retailer and will as the image of the physical product. That may increase their price sensitivity, and not willing to pay more due to the comparison of price. Shankar, Rangaswamy, and Pusateri (2001) pointed out that consumers will consider internet stores have lower operational cost, they should offer a cheaper price then the physical store.

Implications

Theoretical Implications

This study adopted CEV model to examine the linkages between website quality, product usability, consumer characteristics, emotion, shopping value, and price sensitivity toward high-tech product in online and physical shopping process. This study provides further understanding toward consumer price sensitivity between online and physical shopping process. Some related issues are discussed as below.

Firstly, previous researches have mostly discussed the willingness or intention of purchase (Fiore et al., 2005; Kulviwat et al., 2007). However, consumers will have more consideration (such as comparing the product price) to make purchase decision especially in buying high price products such as high-tech products. The study designed two consciousness issues (website quality and product usability) to compare the shopping process of online and with a physical trial product. This comparison research design method, which is rare in prior studies.

Secondly, product usability is quite a common but important construct in marketing journals. Several research (e.g., Mayhew, 1992; Nielsen, 1993) has used it in the human-computer interaction (HCI). Han et al. (2001) even adopted the concept on the research of consumer electronic products and developed a complete measurement scale for product usability. However, not too many studies have used the scale in consumer responses or behavioral intention research. Thus, we adopt product usability as antecedence to test its effect on emotions. The results found product usability has a positive effect on consumer emotions during the shopping process.

Lastly, several research have discussed price sensitivity of online and physical shopping, and focused on the products such as margarine, detergent and wine, which the low price products (Alexandru et al., 2000; Shankar, Rangaswamy and Pusateri, 2001). We used higher price products such as digital camera as research object, which was rare in prior research. Furthermore, we found that a price-range measurement of price sensitivity can be more direct and accurate to reflect the respondents' price perception on the products.

Managerial Implications

We suggest that the manufacturers and the retailer (including internet and physical) should take note on the managerial strategies to attracting consumers. The manufacturers such as Sony, Canon, Casio, and etc., they should survey on the consumer needs, such as what are the functions that consumer would consider usable. We believe that to design usable functions rather then add in too many functions that may not be useful but to make the product too complicated could have more attractiveness to the consumers. For instance, a user friendly interface would let all age range of consumers learn and use easily. Besides, the product images also an important issue especially for the young people. As digital camera to be more common nowadays, they would like to have a modern product, which easy to keep and bring. They can bring it a long all the time and use it whenever they need it.

For the retailer, we suggest that retailer should well train their sales person for wide range of products categories. They can serve and introduce products more professionally based on the customer needs, and also can give them full of solution when they have any question about the trial product. That would be more convincible and the consumer would be more enjoyable in playing the trial unit, and ultimately would enhance consumers' hedonic value during the shopping process, as well as utilitarian value when the product can fulfill their needs. That would eventually lower the consumer price sensitivity.

For the online Internet store, rich content and information are needed including detail of product configurations, the website contact, customer service contact, and etc.. Consumers would be more confident and the website would have higher trustfulness when the website have full of those contents. Besides, more photo image such as 3D panoramic photo should be included in the website. Consumers can play with the 3D image which resemble as the real product. They would feel more enjoyable and excited during the shopping process. Furthermore, we also suggest that online store should not implement price competition strategy to attract sales. They should rather highlight their service, such as convenience, fast response time, information richness and free access.

Limitations and Future Research

There are some limitations in this study. Firstly, the respondents, they were mostly students with lower income. As known young people will browse through the Internet for information when they have a need to make purchase. They may have bias on price sensitivity because they always can compare the price between online and the physical retailer for saving the cost. Future research should extend the population more widely with more age ranges. That would have difference outcome when the respondent have higher income.

Secondly, the research design, we conducted the physical trial product in a small lab, which is not a real environment of physical retail store. Future research should have conducted the study in the real store. That not only can have the results more realistic, but also can have wide range of respondents.

Third, the object (the digital camera) is too general and not the latest version. It may not arouse the innovative feeling of respondents. We suggest future research should use the product which is more innovative such as e-book, iPad, 3D TV, PDA, and etc.. The respondents should be more excited when playing these products.

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CUSTOMER INTIMACY IN ONLINE PERSONALIZED RECOMMENDATION

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ABSTRACT

Relationship marketing emphasizes the importance of developing a long term relationship with customers for selling product. Personalization is a tool for online vender to enhance customer relationship on the Internet. Prior research has treated personalized services as empathetic responses from the service provider to create customer intimacy for building a close relationship with the receiver. In this paper, we focus on investigating the process of customer intimacy development to explain the association between receiver attitudes and personalized services. The intimate experiences of the receivers are composed of cognitive intimacy that includes the perceived communication and perceived care, and affective intimacy that includes commitment, comfort, and trust. To examine the proposed model, we conducted a controlled laboratory experiment using personalized product recommendation through email advertising. The findings indicate that, compared with the control group, the receivers of the personalized service had a significantly higher intimate experience and more positive attitude toward the advertisement and the recommended products. This research significantly extends existing findings and can lead to the development of more comprehensive theories and guidelines for vendors to improve their customer services.

Keywords: Personalization, Customer intimacy, Relationship quality

INTRODUCTION

The marketing activities that are directed toward establishing, developing, and maintaining successful relational exchanges between vendors and customers are referred to as relationship marketing, which focuses on individual-oriented communication aimed at building relationships and increasing revenues (Morgan and Hunt, 1994). In recent years, personalization-related research has received increasing attention in the information systems field. With the rapid growth of Internet users, personalization is commonly used to establish one-to-one interactions. Personalization techniques enable the analysis of a customer's preference from previous purchasing behavior, so advertisers can tailor their ads to that customer's preference in future interactions. Providing personalized messages and product recommendation is considered to be an effective mechanism to establish customer relationship for customer acquisition and retention (Ansari and Mela, 2003; Kotler, 2000; Peppers et al., 1999). For example, researchers found that recipients perceive personalized

email as useful, and are willing to respond to it, which results in more effective advertising (Ansari and Mela, 2003; Tam et al., 2006).

An issue related to the effect of personalization on relationship management is to understand more about the change of vendor-receiver relationships. Personalization can be effective only if this relationship is enhanced. In other words, we can reasonably expect that the quality of this relationship is changed due to personalized services offered by the vendor.

The major purpose of this research is to propose intimacy as a proper measurement of this relationship and explore whether the enhancement does exist when services are personalized. As the Internet has become an indispensable element in our life, most users have built a very close relationship with this technology, but we still do not have a proper measurement to indicate the quality or nature of this relationship. In human relationships, intimacy is often used to indicate a feeling of closeness generated from intimate interaction in order to induce an individual to continue interaction. The extent of developing intimacy in an interaction is an indicator of relationship quality. The concept of intimacy can be used to investigate the relationship building between online service providers and receivers, which may be called *digital intimacy*. This is in line with the argument presented by Liang et al. (2009b). They contended that IT can be used as a personalization tool to build customer relationships and can be treated as an empathic response that results in customer intimacy.

Existing literature in human relationships and marketing has also proposed intimacy as a major indicator of relationships, which includes several cognitive and affective components (such as communication, comfort, caring, trust, and commitment). In this research, we adopt these concepts to postulate that the intimacy factors are strongly related to the positive attitude toward personalized recommendation. Our research questions are: (1) Can personalized services lead to the customer's intimate experience? and (2) Does the development of customer intimacy make personalized services effective in inducing positive customer attitudes? To examine our assertions, we developed a research model. The model was then evaluated in a controlled laboratory experiment to examine its ability to interpret the effect of personalized service delivered through email on customer attitudes.

The remainder of this paper is organized as follows: Section 2 reviews prior literature on personalization and introduces the intimacy construct as indicators of relationship quality for personalized services. Section 3 presents the research model and the hypotheses. This is followed by the description of our experimental design and the development of the measurement in Section 4. Sections 5 report the analyses, the results, and their interpretation. Finally, Section 6 outlines major findings, theoretical and practical contributions, and further future research directions.

LITERATURE REVIEW

Personalization

There are three major categories of research on personalization in the information systems area. The first focuses on examining different types of personalized services and their

potential applications in different marketing domains (e.g., Brusilovsky et al., 2007). The second is dedicated to designing technologies for personalized services with an emphasis on the receiver's profile, and then matching the personalized service with the receiver's needs by using tools such as data and text mining (Shahabi and Banaei-Kashani, 2003; Zhang et al., 2007). The third category evaluates the effect of personalized services on the receivers' attitudes and acceptance of recommendation intention (Komiak and Benbasat, 2006; Liang et al., 2006; Tam and Ho, 2005; Tam et al., 2006). While extensive research has described and analyzed the impact of personalized recommendation agents on email advertising and marketing, recent attention has been given to the issue of why personalization may influence customer attitudes. Therefore, it may be useful to develop theories that help interpret the relationship between personalization and its effect on customers from different perspectives.

In previous literature, there exist at least three perspectives in interpreting the effect of personalization: information and effort reduction, personal persuasion, and relationship building (Liang et al., 2009b). The relationship building perspective adopts the concept of relationship marketing, and treats personalized services as a tool for building a close relationship between the sender and the receiver. Personalized messages intend to develop positive affection between the sender and the receiver. This feeling may include care, trust, and other related emotions. For instance, Komiak and Benbasat (2006) proposed a trust-centered perspective in studying the adoption of personalized recommendation agents. Both cognitive trust and emotional trust have been found to influence the intention to adopt personalization agents. This finding indicates that personalized services can give rise to an individual's emotional process and give the user a sense of togetherness with the personalized service and its provider. In addition, Liang, et al. (2009a) found that perceived care (an emotional factor) was more influential than transaction costs reduction (a rational factor) on the perceived usefulness of personalized services offered by online bookstores. These findings suggest that personalization may have significant affective influence on consumer buying behavior.

Intimacy and Relationship Building

Intimacy is a widely used concept in social psychology and has been adopted for measuring bilateral relationships in relationship marketing, sociology and related fields as a crucial component for building close relationships (Felmlee and Sprecher, 2000). In the process of interpersonal interactions, if an individual perceives the other party as being able to respond empathetically (i.e., understand his/her needs, have concerns about him/her, or pay special attention to him/her), he/she will experience intimacy from the interaction because his/her mental and/or physical needs are satisfied (Laurenceau et al., 1998). Such intimate experiences, then, will stir his/her emotion and entice him/her to keep in touch with the other party so that their relationship can be improved gradually. Accordingly, relationship building is the process of developing intimacy, and intimacy plays a key role in a satisfying relationship (Reis and Shaver, 1988). Hence, it is useful to explain relationships, such as the interdependence of lovers, friends, and families, a bond between a customer and a vendor, or a connection between receivers and personalized services (Ansari and Mela, 2003; Laurenceau et al., 1998; Mittal and Lasser, 1996; Stern, 1997).

Reis and Shaver's (1988) contended that intimacy was an interpersonal process that involved sharing personal information and responding warmly. For the positive feelings to be elicited, one must perceive a partner's response as empathic. Based on this claim, Prager (1995) argued that intimate interactions include intimate behaviors and intimate experiences. He further proposed that intimate experiences in interaction could be divided into the experience of cognitive intimacy and the experience of affective intimacy. Cognitive intimacy refers to the perception of a partner's empathic responses, while affective intimacy refers to the positive feelings about the partner. Laurenceau et al. (1998) further argued that the perceived partner's responsiveness is positively associated with one's positive feelings toward the partner in an interaction. That is, in the process of intimacy development, one's affective intimacy is a result of his/her cognitive intimacy. Several other studies also support this contention (e.g., Gore et al., 2006; Laurenceau et al., 2005). Similarly, White and her colleague (e.g., Paul and White, 1990) have defined three components of intimacy: cognitive, affective, and behavioral. The cognitive component indicates the receiver perceives an emphatic interaction (e.g., good communication and caring), which can lead to positive feeling (the affective component), and intimate behavior. An excellent review of the cognitive-affective model of using information technology is available in Te'eni (2001).

In term of service relationship, Stern (1997) proposed that customer intimacy should include five components: communication, caring, trust (conflict resolution), comfort, and commitment. As the intimate experience is divided into cognitive and affective, the five components can be divided into two groups. By definition, cognitive intimacy is the speaker's positive perception of the listener's response to the speaker's intimate behavior. It is created when the speaker perceives the listener's response as empathic, that is, interprets the listener's response as understanding and caring. Hence, communication and caring can exhibit the characteristics of cognitive intimacy (Gore et al., 2006; Laurenceau et al., 2005; Prager 1995). Affective intimacy consists of the speaker's positive feelings toward the listener, and usually is regarded as the important indicator of relationship quality between the speaker and the listener (Gore et al. 2006). Three components could be used to represent affective intimacy including commitment, comfort, and trust. These three major emotional responses refer to the speaker's validation that the listener is acceptable and worth being in a relationship, and can be viewed as the positive feelings to the listener. To sum up, customer intimacy is composed of five components in two categories: cognitive components (communication and caring) and affective components (trust, commitment, and comfort). The process of intimacy development is the process of experiencing the interaction as intimate, and it could be verified by the effects on the five components.

Attitude toward Advertisement

In existing literature, there are two ways to measure the outcome of advertisement: effects and effectiveness. Wright-Isak and his colleague (1997) stated that effectiveness measures the cumulative contribution to an organization over time, but effects are short-term outcome from a particular event. Advertising effectiveness is concerned with making a tangible contribution (e.g., sales increase) to a company or a brand that must exceed its costs to be considered successful. In contrast, effects often measure immediate changes in consumer affects, attitudes, and behaviors. Therefore, most advertising research focuses on

measuring effects from a limited number of executions and exposures and typically is studied in controlled experiments that employ one exposure to single messages over a short period of time (Wright-Isak, et al., 1997).

A popular measure of advertising effects is the consumer's attitude toward the advertisement because it is found to be a mediating factor that affects purchase intention (e.g., MacKenzie et al., 1986; Bush et al., 1999; Tsang, et al., 2004) and advertising effectiveness (e.g., Metha, 2000). More favorable attitudes can lead to higher purchase intentions. This assertion is supported by many behavioral theories such as the theory of reasoned action (Fishbein and Ajzen, 1975), the technology acceptance model (Davis, 1989), and the planned behavior theory (Ajzen, 1985). Therefore, it is reasonable to measure attitude toward advertising as a good indicator of advertising effects.

THE RESEARCH MODEL AND HYPOTHESES

Figure 1 shows a schematic view of our proposed research model, which is based on the interaction process and on the five components of intimacy described earlier. Personalized response generated by a computer-based system may induce higher level of receiver's intimacy, which in turn induces a positive attitude toward product recommendation. In addition, the intimate experience begins with the perception of the personalized service provider's empathic response (cognitive intimacy), including the level of perceived communication and caring. These perceptions then contribute to the service receiver's feelings of commitment, comfort, and trust toward the service provider (affective intimacy). Finally, the positive feelings lead to the positive attitude toward the recommendation made by the service provider.

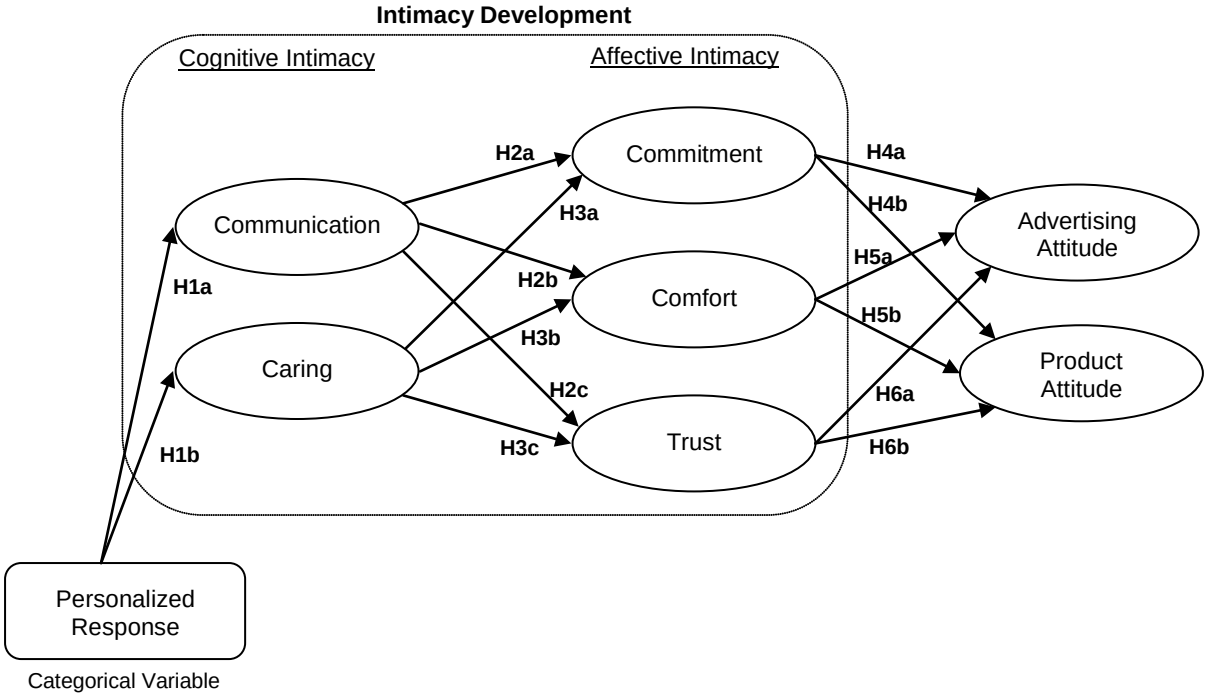

Figure 1: The Research Model.

The Effect of Personalization

The first hypothesis we need to test is whether personalization can lead to intimate experiences. As described earlier, a service provider that offers personalized recommendation should collect the receivers' personal information, so that the personalization agent could analyzes the receivers' preference and the services can be tailored to the receivers' needs. In such an interaction, personalized services that show concern and support can be viewed as an empathic response to the receivers' disclosure of personal information. Therefore, the personalized response will enable the receivers to perceive that they have been understood (validating the successful communication) and been cared for. This can be expressed as:

Hypothesis 1a：Personalized responses from personalization agents can generate a higher level of perceived communication than non-personalized responses.

Hypothesis 1b：Personalized responses from personalization agents can generate a higher level of perceived care than non-personalized responses.

The Influence of Cognitive Intimacy

As intimate interaction begins with one's self-disclosure, successful communication plays an important role in developing intimacy. Successful communication means that the information shared in an interaction has been understood (Stern, 1997; Te'eni, 2001). Communication contributes to the positive feelings for establishing relationships, where three common positive feelings indicate the strength of the relationship: commitment, comfort, and trust (Morgan and Hunt, 1994; Palmatier et al., 2006; Roberts et al., 2003). Commitment is a desire or willingness to attach to the other party and to bond with the other party. Comfort is a satisfied state due to being in a comfort zone with the other party. Trust is a feeling of confidence in someone, showing that an individual feels that the other party's response is genuine rather than pretended or false. In the context of offering personalized services on the Internet, when the service receivers perceive that the service provider has tried so hard to understand what they have to say, they will have a desire to bond with the service provider, perceive comfort in the interaction with the service provider, and feel the service provider is honest. This can be expressed as:

Hypothesis 2a：The level of perceived communication is positively associated with the receiver's commitment to the service provider.

Hypothesis 2b：The level of perceived communication is positively associated with the receiver's comfort in the interaction with the service provider.

Hypothesis 2c：The level of perceived communication is positively associated with the receiver's trust in the service provider.

Caring refers to showing concern in an interaction. In order for an affective interdependence to occur, a listener should not only present understanding and sensitivity, but also show consideration for the speaker's well-being and show willingness to help the speaker (Scharf and Mayseless, 2001; Sharabany, 1994). In terms of personalized services, when the service provider cares about the receiver's needs and welfare, his warm-hearted attitude will make the receiver feel friendly and kind to him. Therefore, the service

provider's benevolence will deeply affect the receiver and elicit the positive feelings from the receiver (Gore et al., 2006; Laurenceau et al., 2005). As mentioned above, commitment, comfort, and trust will also result from the perception of having been cared for. That is, when the receiver perceives that the service provider gives the individualized attention and shows concern, he/she will confirm that the service provider is acceptable and valuable. Accordingly, the receiver will have a desire to commit to the service provider, perceive comfort in the interaction with the service provider, and feel the service provider is honest and trustworthy. Hence, the following three hypotheses are posited:

Hypothesis 3a：Perceived caring is positively associated with the receiver's commitment to the service provider.

Hypothesis 3b：Perceived caring is positively associated with the receiver's comfort in the interaction with the service provider.

Hypothesis 3c：Perceived caring is positively associated with the receiver's trust in the service provider.

The influence of Affective Intimacy on Attitude

Commitment involves psychological attachment to the other party, and is the driver of supporting an individual in showing a particular attitude (Agrawal and Maheswaran 2005; Gustafsson et al. 2005). If an individual is committed to the other party, he/she will have a desire to maintain the relationship with the other party. Consequently, his/her attitude toward what the other party has done will tend to be positive due to the emotional need for satisfying that desire (Malhotra and Galletta, 2005). Drawing on prior research in relationship marketing, commitment has been seen as a vital predictor of a consumer's attitudes, intentions, or behavior from a relationship perspective. For example, several studies have argued that commitment positively affects consumers' behavior, such as retention and actual purchasing (Agrawal and Maheswaran, 2005; Gustafsson et al., 2005; Palmatier et al. 2006). Therefore, when the receiver has commitment to the service provider through intimate interactions, such psychological state will positively influence his/her attitude toward the recommendation made by the service provider. This can be expressed as:

Hypothesis 4a：Commitment is positively associated with the receiver's attitude toward the advertisement provided by the service provider.

Hypothesis 4b：Commitment is positively associated with the receiver's attitude toward the product in the advertisement provided by the service provider.

Comfort is a basic requirement for developing intimacy and it enables an individual to enjoy the interaction with the other party (Stern 1997). If two parties are not in the comfort zone in the process of building intimacy, they will not be able to have a comfortable level of closeness. That is, comfort can be viewed as a satisfied state resulting from the positive overall evaluation of an interaction. Since a sense of comfort refers to a positive feeling toward getting along with another, comfort could significantly influence one's behavior from an emotional perspective (Bhattacherjee and Premkumar, 2004; Gustafsson et al., 2005; Verhoef, 2003). In the context of the interaction between a personalized service provider and receiver, if the receiver feels comfortable with the service provider, such

feeling will lead to a positive attitude toward the recommendation made by the service provider. Therefore, we posit the following hypothesis:

Hypothesis 5a：Comfort is positively associated with the receiver's attitude toward the advertisement provided by the service provider.

Hypothesis 5b：Comfort is positively associated with the receiver's attitude toward the product in the advertisement provided by the service provider.

Trust in its version for intimacy refers to a feeling of confidence in someone, meaning that an individual feels that he/she can trust the other party in an interaction (Prager 1995). That is, the individual feels that the other party is honest. This feeling does not result from a cognitive process; rather, it results from an affective process. Accordingly, when an individual has the feeling that the other party's response in an interaction is genuine, he/she not only is able to experience the interaction as intimate, but also to positively affect his/her attitude toward the other party's behavior (Scharf and Mayseless, 2001; Sharabany, 1994). Therefore, when the receiver feels that the personalized service provider is honest, this feeling will lead to his/her positive attitude toward the recommendation made by the service provider. This leads to the following hypothesis:

Hypothesis 6a：Trust is positively associated with the receiver's attitude toward the advertisement provided by the service provider.

Hypothesis 6b：Trust is positively associated with the receiver's attitude toward the product in the advertisement provided by the service provider.

RESEARCH METHOD

Experimental Design and Procedures

An experiment was conducted to test the proposed model. Subjects were recruited online for receiving a personalized email. The experimental group received a personalized email that contained personal shopping report and an advertisement chosen based on their revealed preference, whereas the control group received a similar but non-personalized email that contained general report and a randomly chosen advertisement. The process began with an invitation to participate which was posted in online communities. Subjects registered and provided their personal demographics, their historical and intended buying preferences, as well as their request for product information. After that, participants were randomly divided into two groups: the experimental group that received a personalized response, and the control group that received a non-personalized response. A manipulation check for personalization was performed. Participants were asked to evaluate the email messages after reading the email. The difference between the experimental and the control groups was significant, which indicates that the manipulation was successful. Finally, there were 463 valid subjects (157 men and 104 women in the experimental group, 114 men and 88 women in the control group). The profile of the subject shows an average of 27 years old, 90% of them holding a bachelor or higher degree, 34% students and 76% non-students, an average of 11years of Internet experience and an average of 7.1 purchases in the past six months.

Instrument

The measurement items were adapted from existing literature. Communication assessed the perception of the degree to which the service provider expressed an understanding of the receiver (Duncan et al., 1998; Ramsey and Sohi, 1997), while caring assessed the perception of the degree to which the service provider expressed its concern (Doney and Cannon, 1997). Affective intimacy includes three elements. Trust was measured by the items adapted from Doney and Cannon (1997) and Komiak and Benbasat (2006), and assessed the degree to which a receiver felt the service provider is honest. Comfort assessed the degree to which a receiver was satisfied with "getting along" with the service provider (Roberts et al., 2003). Finally, commitment was measured the items that assessed the degree to which a receiver had an enduring desire to remain with the service provider (Gustafsson et al., 2005; Roberts et al., 2003). Attitude toward the email advertisement (advertising attitude) and attitude toward the recommended product in the advertisement (product attitude) are used to measure the effect of the recommendation. Advertising attitude was assessed by the items adapted from Brackett and Carr (2001), and product attitude was assessed by the items adapted from Berens et al. (2005). All questionnaire items were measured on a five-point Likert-scale, with 1 being least agreed and 5 being most agreed.

A pretest was conducted to examine the validity and reliability of the instrument. We received 129 valid responses and used a principal component analysis with varimax rotation to check the factor structure in our research model. All items converged into seven intended factors and did not load highly on other factors except one indicator for product attitude. In order to maintain the discriminant validity, the item loading highly on both product attitude and trust was removed from further analysis (Hair et al., 2006). Moreover, Cronbach's alpha values ranged from 0.84 to 0.91 for the seven constructs, indicating a high internal consistency considering a minimum threshold of 0.7 (Nunnally et al., 1994). Therefore, all questionnaire items were retained in the measurement model except the one for product attitude.

DATA ANALYSIS AND RESULTS

Construct Reliability and Validity

PLS was used for assessing the measurement model. As to construct reliability, the composite reliability values for all constructs exceed 0.7. This provided evidence for construct reliability (Hair et al., 2006; Nunnally et al., 1994). With respect to congruent validity, all factor loadings were highly significant in a t-test, and AVE values were greater than the recommended score of 0.5. To support the discriminant validity, AVE values for each construct were greater than the squared correlation estimates involving the construct. Taken together, this evidence supports the convergent validity and discriminant validity of the measurement model (Hair et al., 2006). Thus, our constructs are valid for further analysis.

The Structural Model and Results of Hypotheses Testing

Since personalization was operationalized as a binary variable in the experiment, its effects on cognitive intimacy can be evaluated by using the Student's t-test to examine the differences between the personalization and non-personalization groups. As shown in Table 1, both communication and caring levels differ significantly between the two groups. In the personalization group, the receivers' perception of communication level and caring is higher than the receivers' perception in the non-personalization group. This result indicates that personalized response was viewed as an empathic response expressing understanding and caring in an interaction with service receivers. Therefore, H1a and H1b are supported.

The relationships among cognitive intimacy, affective intimacy, and attitudes can be tested by Structural Equation Modeling (SEM). The resulting model estimations from PLS are shown in Figure 2. All paths are positively significant except the relationship between comfort and product attitude. This indicates that a higher level of cognitive intimacy will lead to the higher level of affective intimacy, which in turn will contribute to more favorable attitudes toward the advertising and product. Regarding cognitive intimacy, the perceived level of communication positively influences the service receivers' commitment, comfort, and trust. Therefore, H2a, H2b, and H2c are supported.

Besides, the level of perceived caring shown by the service provider also increases the receivers' commitment, comfort, and trust. That is, H3a, H3b, and H3c are also supported. With respect to affective intimacy, the receivers' commitment, comfort, and trust are all positively associated with their attitudes toward advertising and product expect that the impact of comfort on product attitude was found to be insignificant. Thus, H4a, H4b, H5a, H6a, and H6b are supported, while H5b is not supported. Finally, the R^2 in the model shows that the model accounts for 51 percent, 46 percent, and 28 percent of the explanation variance in commitment, comfort, and trust, respectively. The affective intimacy interprets 37 percent of the variance in the attitude toward advertising, and 24 percent of the variance in the attitude toward product.

Table 1: The Results of t Test for Two Dimensions of Cognitive Intimacy.

Variables		Mean	S.D.	I - J	t	Sig.
Communication	**P (I)**	**3.42**	**0.65**	**0.27**	**4.538**	**0.00****
	Non-P (J)	**3.15**	**0.63**			
Caring	**P (I)**	**3.38**	**0.73**	**0.68**	**9.979**	**0.00****
	Non-P (J)	**2.70**	**0.72**			

Note: S.D. = standard deviation

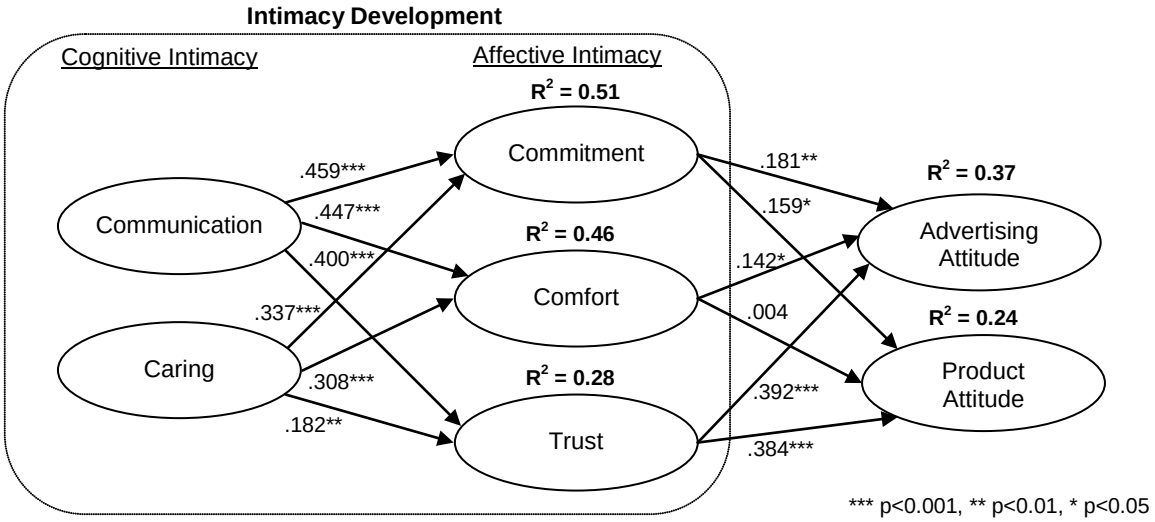

Figure 2: Result of PLS Analysis.

DISCUSSION AND CONCLUSION

In this paper, we have proposed a research model that presents the process of customer intimacy development to explain the effect of personalization from a relationship building perspective. In particular, we have adapted the intimacy theory as our theoretical frame to investigate the role of certain emotional components in the process of delivering and receiving personalized services. Intimacy is modeled to have two sets of components: cognitive (including communication and caring) and affective (including commitment, comfort and trust). Major findings and the contributions are discussed next.

First, the study has shown that the effect of personalized recommendation as measured by consumer attitude changes is partially due to the change in relationship quality derived in the online interaction process. This supplements the prior findings mostly verified that the effect of personalization is generated by cognitive and rational motivations such as least efforts and preference matching. In particular, we have found that intimacy is a good construct to capture the relationship change derived from personalized services.

Second, the ability to show understanding and caring, even when generated by a software agent, plays a crucial and positive role in building relationships with the service receivers. The effect of personalization on building a relationship is effective by means of showing understanding and caring to the receivers. This can have significant implications for the design and delivery of personalized recommendation in electronic commerce.

Third, the intimate experience is composed of two groups of factors: cognitive and affective. Cognitive components represent an individual's positive interpretation about the other party's response, while affective components represent an individual's positive feelings toward the other party. Cognitive components include communication and caring, with communication having a higher impact than caring. Commitment, comfort, and trust are the affective reaction to positive interpretation on personalized service, and are the major factors that affect one's attitude. Trust has the highest impact on consumer attitude,

commitment is second and comfort is the third. This is consistent with research findings in relationship marketing, which consider commitment, comfort, and trust to be major indicators to predict consumers' attitude.

This is an original research that intends to explore the effect of personalization from a relationship building perspective. Although we have done everything possible to ensure its validity, our work can certainly be improved in a number of ways. First, intimacy is an affective construct, which is difficult to define precisely and different researchers may have different perceptions or definitions of the construct for their own purpose. In particular, some people may perceive this to be a concept among human beings. In this research, we have defined it based on our understanding of its role in relationship building and found interesting results. However, the result may change if the construct is defined differently. The second possible limitation of the study is that the data was collected in an online experiment and the context in this study could be different from that of the real world. Therefore, several issues and constraints need to be kept in mind when the results are interpreted, which include: (1) A bias might exist as a result of the subjects being volunteers; (2) The sample may not represent the population owing to convenient sampling; (3) Subjects were offered a limited menu of 36 products and their favorite products may not have been included; and (4) The results might not hold true in different contexts or settings. Even though there are some limitations in this study, our work has extended our existing understanding of personalized recommendation and can potentially open a new lens to view online customer behavior in the Internet age.

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PERSONALIZED ADVERTISING RECOMMENDATION BASED ON WEB MINING AND CHANCE DISCOVERY

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ABSTRACT

Thanks to the vigorous development of Internet technology, Internet marketing has risen as a result. The performance of Internet marketing depends on the design of the web site itself, furthermore, another influential factor is how to attract visitors via web advertisements. It can be deduced that web advertising is a crucial communication tool and marketing medium of the Internet era, which should no longer be displayed at random. It should be able to respond to user preferences immediately and provide recommendations accordingly, which gives way to the idea of a recommendation system. Traditional recommendation systems emphasized on precision of recommendation, their objectives were to provide correct product information. However, the product information recommended only by key characteristics is likely to be consumed quickly and easily. That is why this research hopes to establish the association between terms using KeyGraph algorithm of chance discovery and locate nodes with chance discovery characteristics. These nodes are then used to recommend novel contexts with association network that users may not be aware of intuitively. Meanwhile, the use of web mining technology to analyse users' browsing behaviours helps to understand their preferences and degree of interests in the content of the web page. It can be based to expand the range of recommended advertisements. As well, the combination of web mining and chance discovery will ensure the diversity and continual increase in recommended items, thus providing uninterrupted recommendations.

Keywords: Web mining, Chance discovery, KeyGraph, Personalized advertising recommendation

INTRODUCTION

Because of the vigorous development of Internet technology, web pages have become the fastest growing media whose developing potential far exceeds that of the newspapers, television, radio, magazines, etc. How to utilize the Internet to strengthen the marketing capability of organisations, to communicate with existing customers efficiently as well as uncover potential ones have been the focus of development of organisations. Not only is the performance of web marketing dependent on the design of the web site itself, another influential factor is how to attract visitors, which involves the effect of web advertisements. Web advertisement can be regarded as a synthesis of traditional real-world advertising and personalised marketing. In comparison to traditional media advertisements, web advertising is cheaper, more flexible, more interactive, and allows around-the-clock contact with customers, which makes it easier to evaluate its effect. All of the above advantages make it a crucial communication medium of the Internet era (Timmers, 1999; Whinston et al., 1997).

It can be observed from the current development of web advertising that most commercial web sites have various web advertising display systems. But they generally lack the capability to uncover the potential interests of customers, which is adverse to the attraction of new customers. That is why this research adopts the idea of chance discovery to expand the domain for recommended advertisements in order to boost users' browsing desire. Following the interactions with users' browsing behaviours, the diversity and continual increase in the recommended items will be maintained, thus providing non-stop recommendations.

The objective of this research is to build a personalized web advertisement recommendation model, where real-time interactions are realised through user behaviour. Building such a system will promote user satisfaction in regards to web advertisement and expand the range of advertisements. The results will also boost users' browsing desire. What this research intends to achieve in the web advertising domain is the efficient extension and distribution of personalized web advertising technology, while providing a new direction and a viable operating structure for future research. The features of which are as follows:

(1) This research utilizes chance discovery to establish the association between word terms, and to further understand the potential association between word groups. Applying the chance word to be potential nodes in the association network can expand the domain of recommended advertisements, and provide the advertisements that meet users' expectation.
(2) Past recommendation systems emphasized precision in providing correct product information, but such information was likely to be exhausted. That is why this research

intends to employ the chance discovery theory to locate the novel items that have associations with each other but are not intuitively relevant and to stimulate users' browsing desire.

(3) By employing chance discovery and the continuous interaction concerning user evaluation, it is hoped that this research can discover user preferences and the influence of chance discovery in interaction, so as to introduce information regarding user experiences and group evaluation to the chance discovery ideology. As a result, the precision and functionality of recommendations will be improved and diversified advertisement information and combinations will also be provided.

LITERATURE REVIEW

Chance discovery

Chance discovery is an emerging research subject proposed by Ohsawa et al. (1998), who advocated it in the location of structurally significant information, which does not appear often under the original text mining mode. Such information normally cannot be discovered using the original text mining technology. On the other hand, it is achieved by analyzing information that is either low frequency or contains weak association so as to find out critical chances or information that is beneficial for future decisions.

The primary objective of chance discovery is to learn how to discover rare or novel events. Unlike any common or occasional events, they are exceptional situations that are easily overlooked. In addition to focusing on finding terms and association that appear frequently but are easily overlooked in data mining, chance discovery emphasizes on the discovery of terms and association that contain the features of being rare and structurally important.

In employing chance discovery, the emphasis is on the analysis of information importance from two perspectives. The first perspective is the term frequency that locates the rare feature, and second the structural relationships produced by association links. That is, the co-occurring frequency of terms and the location of "structurally important" characteristics. From there, information with a strong association and low frequency in relation to association network will be found, and professional knowledge will be applied to explain the information behind the association. The analysis of such information will aid decision-making. There are two kinds of definitions in chance discovery, they are elaborated as below:

(1) New event or situation which is assumed to contain chance or risk, and the information is likely to be a fragment.

(2) Ones that contain characteristics that cannot be explained by data analysis or data mining. From the perspective of frequency, they are data yet to be described or detected.

From the above two definitions of chance, it can be gathered that, Ohsawa (2002) believed chance discovery emphasizes the possibility of discovering events that are crucial in future decision-making under circumstances with no or very little past information available. For example, in the business field, with no past purchasing information available regarding the products, how does one predict customer needs accurately for a new product? This is exactly where Ohsawa (2003) deemed that chance discovery would play an important role.

KeyGraph

Chance discovery frequently relies on KeyGraph to analyze a large quantity of documents to find terms with high frequency, thus producing word groups with high relevancy among them. Terms that do not show up frequently but are keys to the structure of word groups are also disclosed. The utilization of KeyGraph is to discover feature terms that are rare and less frequent, but contain significant structure and are eventually turned into graphs, thus allowing decision-makers to excavate strategic plans that possess key chances.

KeyGraph is a document index or an algorithm of keyword extraction based on graph theory. Similar ideas have been applied on the extraction of English keywords, thus the applications of ideas expressed by KeyGraph on text mining are elaborated as follows:

(1) Find the most frequently appeared event among a series of events, and find the combination of co-occurring events with highest frequency. Such combination of events is regarded as a cluster (Wang and Zaiane, 2002). In text mining, it would be conducted by finding terms with top frequency of appearance and setting threshold values to eliminate words with low frequency. For instance, if the threshold value is set to be 3, then any terms appearing below 3 will be discarded in order to find event combinations that have appeared more than 3 times.

(2) In serial events, co-occurring event combinations will form different clusters, and the nodes that connect them are hubs which are crucial connectors, whereas the associations between clusters are called bridges. The application of this in documents is the construction of links by computing the weight values between high frequency terms. For example, node of term A and node of term B both appear in certain sentences and by translating them into a graph there demonstrates a link between the two nodes.

Web mining

In regards to the structure of web mining, Cooley et al. (1997) proposed the structure and classification of web mining. They divided web mining into seb content mining and web usage mining, which are adopted by this research. Web content mining processes the content of web documents and extracts useful information. Such document data need to satisfy the intended content, which include texts, pictures, audio data, video data or structural records. Generally speaking, a frequency threshold value of web page browsing will be set after the process of web content mining, and when the frequency browsed by a user on certain web pages exceeds this value, then the web content mining system will be activated to retrieve the page from web page database. User profile will then be built from the data obtained through mining, which will serve as a base of recommendation. Web usage mining, on the other hand, discovers the access modes of users from web site access log. It uses web site server logs to analyze and find users' browsing conditions and tendency once they enter the site, thereafter defines their access modes.

Personalized advertisement

Adopting personalized technology to provide personalized web advertisements, the most widely employed technique is the designation of advertisement attributes by advertisers. When users browse a certain page, the web advertising server will display similar advertisements based on the page type. However, such technology is not a user-centric personalized technique, therefore the result is not satisfied (Kramer et al., 2000; Manber et al., 2000).

Another technology that targets at the short-term use preferences of users is achieved on search-based web portals. Based on the search keywords entered and then the use of word matching technology, web advertisements that contain such attributes from web advertisement database will be displayed once the keyword entered and the feature term share a certain degree of similarity. The advantage of this is that it is real-time, whereas its disadvantage is that it does not cover user preferences in the long run and it is unable to record user interests. As a result, the chances to obtain user information will be lost (Langheinrich et al., 1999; Tomlin, 2000).

There is another personalized web advertising technology that applies an agent at user site. The agent retrieves and records user behaviour on the Internet, and displays personalized web advertisements accordingly. Such technology covers both long-term and short-term interests of users. However, it needs users to install an agent before being able to give any

recommendations, and users might consider this as an intrusion of privacy, therefore the challenge of this technology lies in winning user's trust.

The latest personalized web advertising technology adopts web mining to analyse users' browsing behaviours online as well as to obtain their preferences and interests. Li (2000) proposed the use of sequence mining in web mining to build browsing trees representing different user browsing behaviours. Under this mode, the information is classified according to past user characteristics, and browsing trees that are able to predict the behaviours of new users will be built, thus providing suitable advertisements. Such technology primarily determines the web page browsing sequence of users, but it does not take into account the accompanying degree of interest of each node within the browsing tree. Judging on the pros and cons of each method and technology, this research intends to employ web mining to conduct advertisement recommendations.

RESEARCH METHODOLOGY

One of the objectives of this research is to expand users' interests and browsing domains. The use of chance discovery can finds information that is otherwise difficult to find when using methods such as term frequency analysis or association rule analysis. It adjusts according to changes in users' interests and instantly recommends personalized advertisements. This research utilized data mining technology as the foundation for customer-targeted advertisement display. As illustrated by figure 1, such system has the advantages of being personalized and target-oriented in addition to being a real-time interactive recommender. Instead of analyzing the registered information of users, it analyzes user interaction online (as indicated by dotted lines in figure 1), and based on which recommends real-time advertisements.

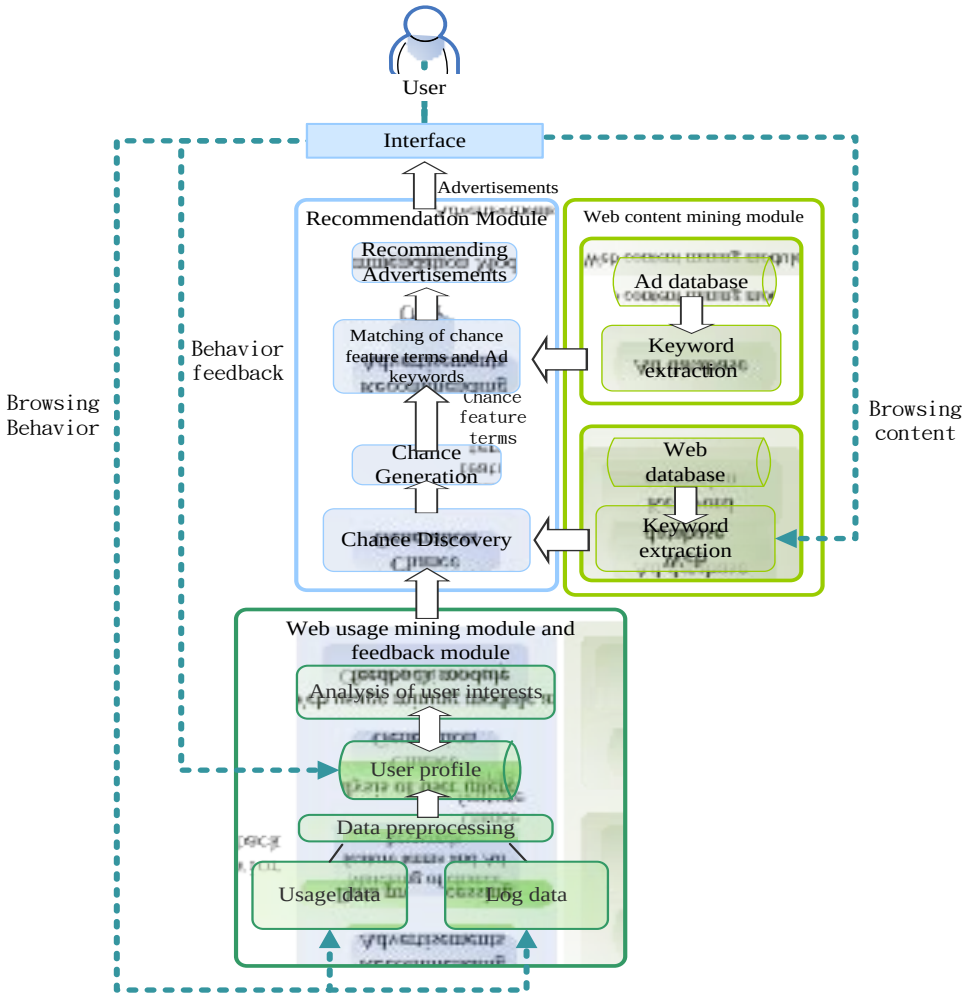

Figure 1: Recommending system of personalized advertisements.

The structure of this research can be divided into web content mining, web usage mining and chance discovery. The part of web content mining filters content and searches for representative keywords within web pages, whereas the part of web usage mining analyses user operation or browsing behaviour online to build user profiles. The degree of user browsing interests is obtained via web mining technologies and the system recommends different contents to different users who are browsing the same item. The chance feature terms, which are produced by chance discovery, are employed to search for advertisements that contain feature terms that are highly similar to the chance node information so as to enable advertisement recommendations (Madira et al., 1999).

Web usage mining module

When users browse a web page, they are aware of their responses to the article and its content, whereas user operating mode allows direct observation of such. That is why this research observes user operating habit online to estimate the degree of user preferences

regarding the web pages. In regards to user web usage mining, this research utilises instant online processing to uncover the behaviour.

Web content mining module

Currently very few researches supply information recommendation based on analysing web page content. But taking into consideration that users browse a certain web pages, because they contain ideas that interest them. That is why this research analyses web content.

In order to understand user interest, this research makes use of the CKIP system developed by Academia Sinica to analyse browsed web content and types. The use of CKIP filters through morphological features and gets rid of articles, prepositions, conjunctions as well as words that were irrelevant to the ideas of the documents, thus reducing meaningless feature terms. Thereafter, the research adopts TF-IDF weight approach as the standard to measure the importance of words, and only those within the top 40% are used as keywords of the web pages.

Similarly, web content mining is also conducted on web pages containing advertisements to allow matches with those chances produced by the chance discovery approach, and provide recommendations of advertisements with similar chances.

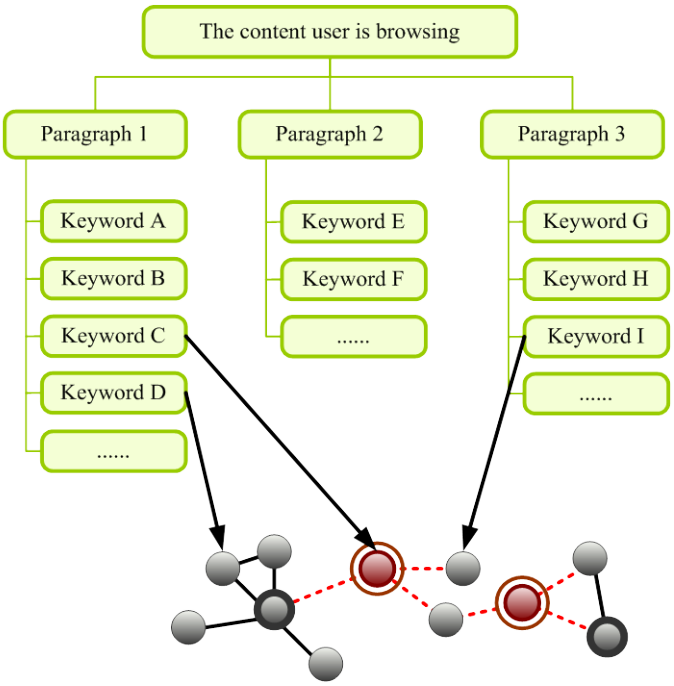

Figure 2: Web page change and its corresponding keywords.

Each web page produces different word segmentations, therefore the word segmentations of first paragraph in a page can be represented as ($P_{1,1}$, $P_{1,2}$, …, $P_{1,k1}$) and the word segmentations of n^{th} paragraph can be represented as ($P_{n,1}$, $P_{n,2}$, …, $P_{n,Kn}$). The length of each page varies, as a result the last word segmentation of the first paragraph is represented as $P_{1,k1}$, and the last one of the last paragraph as $P_{n,Kn}$. However, Kn varies in relation to the length of the content, therefore it is used to represent an unknown word segmentation integer, and the correlation between its keywords and web content is as shown in figure 2 (Salton & McGill, 1983).

Recommendation Module

What distinguishes the advertisement recommendation technology of this research from that of the traditional is that, it takes into account rare and meaningful information. That is, the employment of chance discovery to locate the relevance in features among web content, which ultimately produces chances. Potential domains of user interests are excavated by building the associational network among web pages, thus supplying advertisements that meet user expectations.

Past advertisement recommendations utilised basic user information as the basis of analyses, but this involves the issue of privacy and would cause inconvenience for users. In addition, users must log in to enjoy the recommendation services. As a result, this research adopts web content as the basis for analyses to recommend advertisements. The combining of web content and chance discovery are as illustrated in Figure 3. In terms of advertising information processing, feature terms that represent the web content of the advertisements are located, and an advertisement database is also built. When chances are produced by chance discovery, they would be matched with advertisement database to find identical feature term so as to enable recommendations.

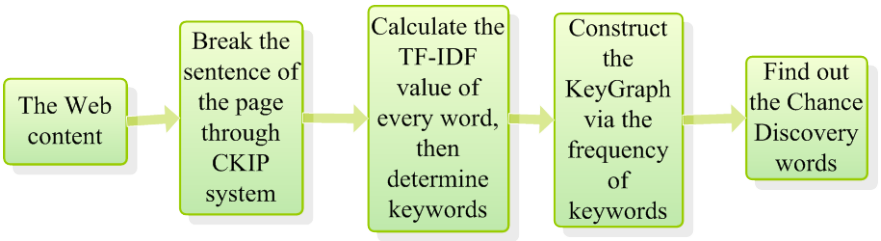

Figure 3: Keyword processing procedure.

Due to the fact that user browsing behavior is continual, this research uses web usage mining to record browsing history, so as to analyze the keywords within the page browsed and makes up a number of key graphs formed by web content, from where the chance nodes are located to perform recommendation. The chance discovery approach employed

by this research not only takes into account the content browsed by users at the time, but also those that are previous browsed. The browsing history is then merged into the analysis information. Furthermore, the evaluation given by other users is also considered, where opinion and feedback are included in the analysis.

Feedback Module

Other than basing the chance combinations of the advertisement pages on user evaluation and then provide feedback, the information contained in the advertisements would also be adjusted based on the evaluation. The value of such is computed using formula 5; when it is smaller than 1, it would not appear in the advertisement combinations of the chance discovery experiment.

DESIGN AND ANALYSIS

Research design

As illustrated in figure 4, the experiment procedure of this research will be elaborated further. Users are required to enter the experimental web site, and the log in information is not included in the analysis. The point of logging in is to observe the course of operation of the subject, and the reminders are given when required, or in the case of failing to complete the experiment the information is removed.

Figure 4: Experiment procedure.

Data source and experiment subjects

The experimental data of this research are collected from the shopping page of Yahoo!Taiwan (http://tw.shopping.yahoo.com/). The advertisement data from the site are used to simulate an advertising platform. There are 300 advertisements and 200 entertainment and recreational web content data collected. The data include user browsing content as well as log files, where the former is retrieved by web spider. To avoid confusion likely to be caused by multimedia objects, web mining would only be conducted on words in

order to obtain accurate data.

The duration of the experiment is one week and is divided into two phases. There are 75 subjects during phase one, and 35 in phase two that are made up of young and frequent users of the Internet. The structure of the subjects from both phases is identical, and their standard error is 0.087.

Experiment conditions

An advertising platform is designed, which allows subjects to access any web pages that might interest them, and based on the content, chance discovery as well as web content mining would then be conducted. User behaviour is recorded utilising web usage mining and an examination would then be made by taking the above as well as questionnaires into consideration. To avoid user fatigue from browsing excessive advertisements, the experiment was conducted in two phases. The first was done based on traditional high frequency and chance discovery advertisements; phase 2 then asked users to evaluate based on experiences and group chance discovery advertisements. After the application of KeyGraph algorithm, each web page can construct a key graph based on its content. As shown in figure 5, the chance discovery feature words retrieved from the content of the web page consist of “sites”, “travel” and “seafood”. “Scenery” and “itinerary” are the high frequency terms, the recommended advertisements would therefore be based on these words.

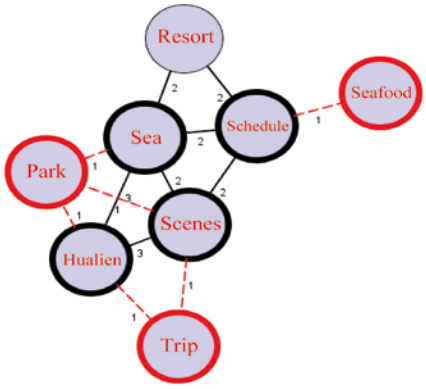

Figure 5: Web content key graph.

Initially, figure 5 is an example of “Hualien” (a city in Taiwan) travel page browsing, and based on the high frequency characteristics, travel advertisements highly relevant to the page would be recommended. In addition to providing relevant travel information, chance discovery would also provide that of other regions due to the low frequency of the recommendation basis. Advertisements associated with “Hualien” or travel will be

recommended. However, these advertisements are different from those of high frequency combinations. Based on the result of this experiment, chance discovery would locate advertisements associated to “parks”, “travel” and “seafood”. Technology products related to travel and food information related to seafood would be picked up.

The advertisements are resulted from the experiences from chance discovery of experiment three. The recommendations are based on “Japanese-style”, “fresh” and “parks” from figure 6, because the subject had previously browsed a page related to Japanese cuisine. As a result, chance discovery is applied based on the browsed web content to find the two pages that can be linked via the term “Japanese-style”. That is why the advertising from experiment three recommends information that contains the feature.

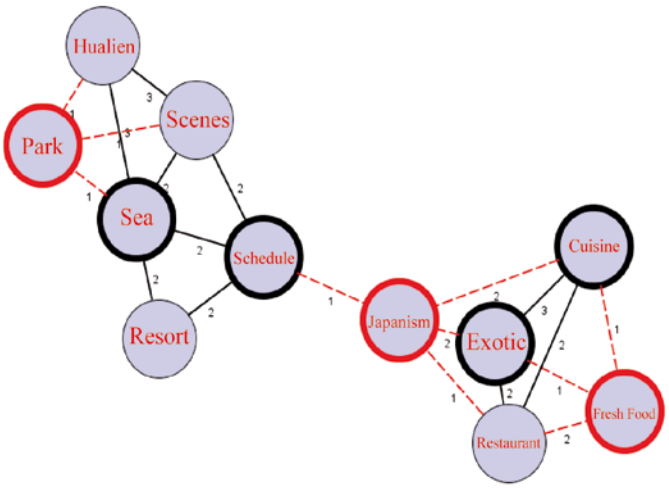

Figure 6: A key graph that combines experience from chance discovery of travel and food.

However, if the subject had previously browsed web content that contains digital appliances, then “Japanese-style”, “fresh” and “cameras” could become the bases of recommendations. As illustrated in figure 7, while browsing web pages about food or travel, users would receive advertisements containing that features. The advertisements within the dotted line in figure 8 are the group chance discovery from experiment 4. While browsing the “Hualien” web page, because other subjects evaluating the page and advertisements concerning “seaports”, “seafood”, “sites” and “parks” have the relevant features of chance discovery, therefore a key graph on the content of the two is constructed to locate the nodes of chance discovery.

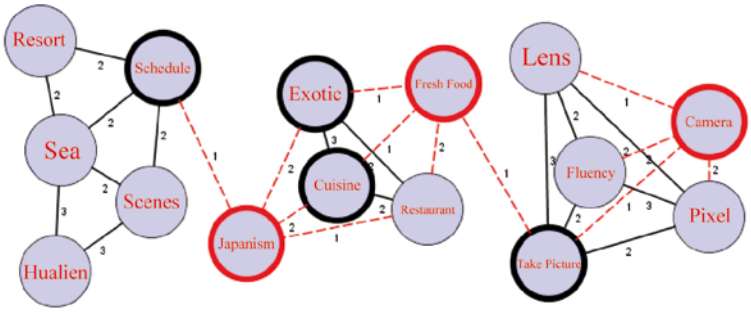

Figure 7: A key graph that combines digital products, travel and food.

As shown in figure 8, the nodes are “travel”, “seaports” and “sites”, thus the recommendations of advertisements contain these. Due to the fact that the experiment has many subjects, each web page would change its recommended advertising due to the varying user evaluation. If a new subject deems the “Hualien” web page and advertisements about off-shore island travel and the feature connection of chance discovery, then the key graph of the advertisement and the web page would be as illustrated in figure 9. The recommended advertisements by the group chance discovery of this page would be based on “off-shore islands”, “seaports” and “sites”.

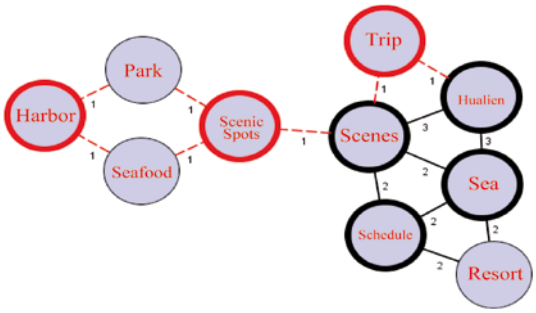

Figure 8: Key graph 1 of group chance discovery.

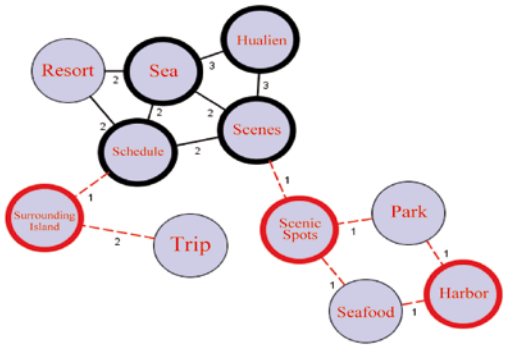

Figure 9: Key graph 2 of group chance discovery.

Experiment design

There are four kinds of recommendation experiments conducted by this research, which are elaborated below. The advertisements recommended are recorded in each experiment. Furthermore, if users do not undertake evaluation, then the evaluation data and information regarding users would not be included in the analysis.

Experiment 1: conventional high frequency feature recommendation

Based on the TF-TDF value after word segmentation, conventional high frequency retrieved the top 20% of keywords as the basis of advertisements search. Just like keyword advertisements, the advertisements recommendations were based on the keywords contained in the Web page

Experiment 2: conventional Chance Discovery recommendation

Based on the TF-TDF value after word segmentation, conventional Chance Discovery recommendation retrieved the top 40% of keywords as the characteristics of the Web content. Term nodes of low frequency and contained network connectivity were found utilising the key chart algorithm of Chance Discovery. The use of these nodes as the basis of advertisement recommendations enabled an extension to other advertisement types.
This research adopted Formula 1 to measure whether users regarded the advertisements corresponded to the feature of Chance Discovery, and utilising their evaluation to work out $Chance_{Value}$. The Formula is as below:

$$Chance_{Value} = \begin{cases} \dfrac{Interest_{Score}}{\mathrm{Re}lation_{Score}} & ,if\ (\mathrm{Re}lation_{Score} > 1) \\ 0 & ,if\ (\mathrm{Re}lation_{Score} = 1) \end{cases} \quad (1)$$

$Interest_{Score}$ represents the evaluation score users had given to the advertisements. That is, the degree of preferences or interest that users had towards the content or item. $\mathrm{Re}lation_{Score}$ represents the degree of relevance between the advertisements and Web content deemed by users. $Interest_{Score}$ and $\mathrm{Re}lation_{Score}$ were divided into 7 levels in this experiment, so as to allow users to reflect in details the degree of relevance between the advertisements and Web content.

Although the method of evaluation was tiered, errors were still likely in the judgement of relevance. But due to the difficulty involved in the using of questionnaires or other methods of response, this method was still adopted.

$Chance_{Value}$ represents the likelihood of the advertisement meeting the features of Chance Discovery as regarded by users. If it was 1, then the advertisement did not contain such features. If it was greater than 1, then the advertisement contained such features and a low frequency but important network connectivity. Even though the advertisement had no strong association with the Web content, it was still able to arouse user browsing interest.

If $Chance_{Value}$ was smaller than 1, then the connection between the advertisement and Web content was greater than user preferences, and would not be the desired information. If $\mathrm{Re}lation_{Score}$ equalled to 0, then the evaluation was given based on user preferences and had no relevance to the Web content, which would not be taken into account.
At this stage of the experiment, Web Usage Mining and Formula 2 would be employed to discover information containing representative and Chance Discovery features. In other words, information with $Usage_n$ greater than 1 would be recorded and used as the recommendation basis during the group experiment of phase 2 (Hou X. R. 2003) .

$$Usage_n = \frac{Content_n}{Average(Content)} \times \frac{Time_n}{Average(Time)} + \frac{Time_n}{37 + (2 \times Count(Ad))} \qquad (2)$$

$Content_n$ indicated the size of the Web content and $Average(Content)$ the average size of Web content in the database. $Time_n$ would be the amount of time that users spent on browsing the page, and $Average(Time)$ the average browsing duration of the page in database, which would enable the determination of the meaning of a particular user among the group information. The form of $2 \times Count(Ad)$ represents the advertisement recommendation feedback from users within each Web content. The inclusion of the experiment time allowed the estimation of the actual browsing time. $Count(Ad)$ indicated the advertisement quantity, with 2 being the shortest time value spent by users on each recommended advertisements plus 37 seconds to obtain the threshold value (MIC, 2001a), in order to work out whether the amount of time users spent on reading the Web page exceeded the threshold value. When $Time_n / 37 + (2 \times Count(Ad))$ exceeded 1, it indicated that users had greater interest in the Web page.

Experiment 3: experience Chance Discovery recommendation

This experiment utilizes personal browsing experience as the basis of recommendations As

gathering together web pages browsed by users would give an indication of their domain of interest, recommendations are supplied based on such information. When users continue to browse the next page, based on the browsing behaviour of the previous page, $Usage_n$ value is worked out to find out if any behaviour is already available for this page. If the outcome is positive, then the $Usage_n$ value from prior browsing would be added to this computation, otherwise only the $Usage_n$ value of this browsing would be taken into account.

Meanwhile, should user browsing behaviour be continuous, compare it with the chance from the previous page. If the two chances are identical, then utilise the chance and give recommendations. If the chance nodes of the two are different, get the record of this particular user and undertake a key graph computation of web content with the top 5 $Usage_n$ value, so as to find the information node of the overall chances to give advertisements recommendations.

Only current user experience information from experience chance discovery experiment would be used, therefore those from phase one would not be included in the analysis. When new users join as new subjects, advertisements recommendations would function based on its browsing experiences, and this would not affect the outcome of the experiment.

Experiment 4: group Chance Discovery recommendation

This part of the experiment is designed based on personal browsing preferences and group recommendation. Recommendations are based on user and group evaluation of the advertisements. This research employs formula 3 to compute the degree of chance recognition users have on the web content, and the use of formula 4 would estimate the chance recognition of the group. Both Formulae are demonstrated below:

$$Interest_{person} = \sum Chance_{Value}, Chance_{Value} > 1 \quad (3)$$

$$Interest_{Group} = \frac{\sum Chance_{Value}}{People_N}, Chance_{Value} > 1 \quad (4)$$

$Interest_{person}$ represents the sum of advertisement evaluation $Chance_{Value}$ that users have during this browsing. In other words, it is the degree of acceptance users have shown regarding chance discovery characteristics advertisements during the evaluation. $Interest_{Group}$ indicates the average $Chance_{Value}$ value of the advertisements on the web

page that all users have after browsing the page. $People_N$ represents the number of users, whereas $Interest_{Group}$ can be regarded as the average value that users have on the degree of chance discovery between the advertisements and web content

During the experiment, when $Interest_{person} > Interest_{Group}$, the advertisements recommendation of user's next web page would give preferences to chance discovery advertisements constituted by the user alone, thus all the information received would be focused on what the users prefer.

When $Interest_{person} < Interest_{Group}$, then preferences will be given to chance discovery advertisements constituted by the group, which means the degree of group chance recognition is higher than that of the personal, therefore the recommendation based on the group. Should the two values be equal, then recommendations would be based on the advertisements combination of individual and the group.

Feedback Module

As the experiment progresses, the advertisement evaluation given by subjects is recorded and examined utilising formula 5 to determine whether or not to recommend the advertisements.

$$Ad_{Value} = \frac{\sum Chance_{Ad}}{N} \times \frac{\sum Interest_{Ad}}{N} \quad (5)$$

Ad_{Value} represents the degree and $\sum Chance_{Ad}$ the total evaluation of chance discovery characteristics of the advertisement, whereas N is the number of appearance. $\sum Interest_{Ad} / N$ is the weighted concept, and $\sum Interest_{Ad}$ represents the sum of interest that users have towards the advertisement. When the chance discovery characteristics of the advertisement is greater than 1 and the higher the user evaluation, then the probability of it appearing is greater. If one of the values is smaller than 1, which means that the advertisement contain no characteristics of the chance discovery or user evaluation is not ideal, therefore it would not appear in the recommendation.

Experiment results and analysis

System efficiency analysis

Analysis and examination of the variances produce results as illustrated in Table 1. When the test statistic P-value of frequently browsed product information is smaller than 0.05, null hypothesis is thus rejected. It goes on to show that subjects, who frequently browse product information, demonstrate a clear association in the impression between recognising high frequency characteristics and chance discovery. If the test statistic P-value of dining is not smaller than 0.05, but is close to the threshold value, it can also be gathered that subjects demonstrate a clear association in the impression between recognising frequency characteristics and chance discovery.

Users browsing product information and those browsing dining would expect different information, and in addition to hoping that the system would provide searched content, it would also provide recommendations or relevant information. For example, users browsing dining pages would wish the system to recommend similar type of food after being presented with the search result, or they would like to know of other restaurants within a similar price range etc. On the other hand, users who browse product information would share the same mentality. So in hoping that the system would not only provide product information, the related products could also be presented. This can equip users with more information before making a decision.

Table 1: ANOVA on subject advertisement preferences and their most frequented web pages.

Most frequented web pages by users	DF	MEAN SQUARE	F Test	P'[-VALUE
News	2	0.180	1.251	0.292
Science and Technology	2	0.212	0.833	0.439
Travel	2	7.171E-02	0.280	0.757
Entertainment	2	0.278	1.110	0.335
Business	2	5.043E-02	0.291	0.749
Product information	2	0.812	4.484	0.015
Online Shopping	2	5.865E-02	0.234	0.792
Auction	2	0.127	0.547	0.581
Art and Culture	2	0.155	1.068	0.349
Dining	2	0.605	2.712	0.073
Health and Care	2	0.172	1.268	0.287

From the outcome of the analysis, it can be seen that utilising the advertisement feedback

module design of this experiment that user evaluation of advertisements was closely related to the relevance of the Web content. As illustrated on Table 2, the result meets the objective of the experiment. The system provides subjects with advertisement pictures, the advertisement itself as well as a combination of advertisement information. However, it seems that the subject evaluation of advertisements is influenced by the experiment topic, and does not base their choices upon personal preferences.

Table 2: Analysis of system efficiency.

System Efficiency Analysis		ANOVA Result
1. H1 Advertisement evaluation analysis		
H1-1：	The subject evaluation of advertisements is not affected by pictures contained in the advertisements.	P-value > 0.05, null hypothesis not rejected.
H1-2：	The subject evaluation of advertisements is not affected by objects contained in the advertisements.	P-value > 0.05, null hypothesis not rejected.
H1-3：	The subject evaluation of advertisements is not affected by the association between the advertisements and web content.	P-value < 0.05, null hypothesis rejected, which indicated a clear association between advertisements and Web Content and evaluation.
H1-4：	The subject evaluation of advertisements is not affected by advertisement combination.	P-value > 0.05, null hypothesis not rejected.
2. H2 Online habit analysis		
H2-1：	The Subject preferences of advertisements are not affected by the average of time spent online.	P-value > 0.05, null hypothesis not rejected.
H2-2：	The subject preferences of advertisements are not affected by browsing experience.	P-value > 0.05, null hypothesis not rejected.

System Satisfaction Analysis

As demonstrated in Table 3, the idea of Chance Discovery can indeed expand the range of advertisement recommendation. The use of browsing history can furnish users with interested advertisements, and a network can be constructed based on browsed domains.

Gathering from the experiment result, the coverage and chance discovery value of the group is higher, which means the design is capable of expanding the range of advertisements to diversity. It also means that the advertisements recommended are more likely to contain

characteristics of chance discovery. In other words, it is relevant to the web content, but is still able to recommend advertisements of other domains, as illustrated by Table 3.

Table 3: System accuracy indices.

			Conventional High Frequency Characteristics	Conventional Chance Discovery	History Chance Discovery	Group Chance Discovery
Average Error Ratio			6.85%	10.29%	6.32%	15.20%
Inversion Coefficient	Satisfaction Rate	High Inversion	0.68%	0.74%	2.11%	4.00%
		Low Inversion	4.79%	3.68%	2.11%	4.00%
	Degree of Relevance	High Inversion	2.05%	1.47%	2.11%	1.60%
		Low Inversion	2.05%	3.68%	0.00%	4.00%

In comparing the group chance discovery and historical chance discovery, taking into account the inversion coefficient and average error ratio, and the kurtosis and skewness of chance discovery, it can be discovered that the outcome of the latter is more stable and with little variability (Papagelis et al., 2004; Sarwar et al., 1998). The improved chance discovery can be divided into that of history and group during the discussion. It is understood from the experiment that users are relatively more satisfied with the advertisement recommended by the former. As shown in Table 4, the recommendation is based on the web content that users are browsing at the time. Therefore it is adaptable to the domains browsed.

Table 4: Satisfaction in system recommendation.

		Conventional High Frequency Characteristics	Conventional Chance Discovery	History Chance Discovery	Group Chance Discovery
Average Rate of Satisfaction		73.97%	63.97%	78.95%	74.40%
Accuracy		74.11%	59.96%	75.11%	75.98%
Advertisements Satisfaction	Average	4.31	3.88	4.32	4.24
	Standard Deviation	1.82	1.87	1.67	1.57
	Mode	4	4	4	4
	Kurtosis	-0.91	-1.08	-0.77	-0.60
	Skewness	-0.28	-0.04	-0.31	0.10

A detailed analysis of the characteristics of chance discovery in this experiment, while excluding samples that evaluate the advertisements solely on personal preferences, would

result in the trend and phenomenon of the three chance discoveries as shown in figure 10. The data indicated that the average of group chance discovery is higher, but its standard deviation and the distribution of kurtosis are evener, and its skewness shows that the distribution of its $Chance_{Value}$ is on the lower side. Although the average of historical chance discovery is not as high as that of the group one, its distribution is more concentrated; and judging from the skewness, its distribution is inclined to higher $Chance_{Value}$. As to conventional chance discovery, even though its kurtosis is more concentrated in comparison with that of the group and its skewness value lower, its standard deviation and average are both below that of historical chance discovery. As a result, judging from the outcome of the analysis, history chance discovery better matches the objective of this research.

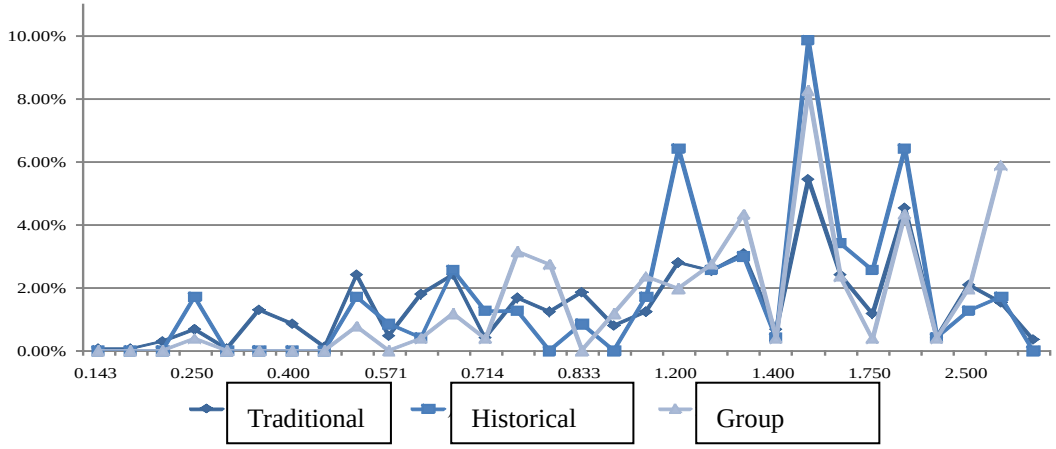

Figure 10: $Chance_{Value}$ from each experiment.

CONCLUSION

The reason behind building an advertisement recommendation is simple, to increase revenue. In order to achieve this, the recommendation system must be able to provide the accurate advertisements in the first place. In other words, the items in the recommended list must be relevant to consumer data or purchase history. If the information is correct and the consumer has such need, then the list will quickly run out. It is therefore important that the list contains items that are “associational but not relevant intuitively” and “fresh”, so as to stimulate the will to purchase. To maintain the diversity and richness of the list, the reciprocation between the addition of new items and the purchase behaviour was essential.

Gathering from the result of the experiments, the idea of Chance Discovery can indeed assist the expansion of domains recommended, and the use of Web Usage Mining helps to filter out meaningful of representative information, thus aiding the construction and correction of

web nodes within chance discovery.

The results of recommendations are likely to be limited by the incompleteness of information as well as the lack of features in terms and lead to the discovery of chance that is already known to users. If the recommendation study can retrieve terms at greater precision, so as to provide more detailed information for the analysis, then it is more probable to excavate the potential need that would otherwise be difficult to uncover.

Currently online advertisements are actively provided to users, but they do not necessary meet the demands of users, and often cause information overload. Although present day online advertisements are pretty self-sufficient, there still is a lack of understanding in terms of user interest. As a result, the recommended advertisements do not meet user need and their domains are limited, which leads to an inefficient outcome.

The contribution of this research lies in the proposal of a personalised advertising recommendation structure. Under the influence of uncertain decision-making in the dynamical circumstances, the proposal of Chance Discovery provides a novel and alternative solution.

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HOW E-SERVQUAL AFFECTS CUSTOMER'S ONLINE PURCHASE INTENTION THROUGH CROSS-CULTURE COMPARISON?

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ABSTRACT

Nowadays, Internet has become the best popular one of the consumers' shopping channels. However, there is different in online shopping situation is because of consumers in different cultures and countries have different online shopping behavior is worth to discuss. This study is to compare the cultures effect in different of online shopping situation between Taiwan and Malaysia. There were 120 questionnaires collected from Taiwan respondents and 118 questionnaires from Malaysia respondent respectively. Statistical analysis software SPSS 17.0 and AMOS 6.0 were used to analyze the impact among two countries on e-service quality, satisfaction, trust, and purchase intention. The model fit of this study was in an acceptable level, and this indicates that the theoretical model of this study supports the description of e-service quality for e-retailers that online shopping situation will be effected by trust and satisfaction. But caused by the cultures in online shopping situation and the relationship on e-service quality to trust and satisfaction have significant differences between two countries. Hofstede's culture dimensions analysis was used in this study and it shows that the uncertainty avoidance index of two cultures meets Hofstede's research. It makes the differences in culture affect the process in online shopping. The result of this study will be available for those who interested in developing a transnational e-retailer as a reference, as well as academic research on cross-cultural comparative analysis.

Keywords: Culture, Shopping Behavior, Trust, Satisfaction.

INTRODUCTION

With the development of information technology and the application of Internet become more and more popularity, the Internet population is increasing every year. Until 31 December 2009, the world online population has reached 1.8 thousand million of which was led by Asia, up to 7.6 hundred millions Internet users. Europe placed the second which has up to 4.2 hundred millions internet users. Among the Internet users in Asia countries which was led by China, up to 3.38 hundred millions Internet users. Malaysia and Taiwan placed at the ninth and eleventh which have up to 17 millions and 15 millions respectively (Internet Usage and World Population Statistics, 2009).

According to Nielson (2009), the number of Internet shoppers up 40% in the past two years and more than 85% of the world's online population has used the Internet to make a purchase. Among Internet users, the highest percentage shopping online is found in South Korea, where 99% of those with Internet access have used it to shop. Before year 2008, only 5.9% of Malaysia population has shopped online. From the survey, seven in ten consumers claimed to have made a purchase over the Internet before. In 2009, Taiwan maintained the growth trend of online shopping market. The market between Malaysia and Taiwan has a great gap in contrast.

This market trend has contributed many retailers know how to simplify the operation of the website to attract consumer. There is no frontier in Internet, so the retailers not just have to understand how the functions and services should be provided; they also have to find whether the same functions matched in other countries. This study attempted to do the evidence research and to be directed against the consumer of Taiwan and Malaysia's baby and children online store through online questionnaire. The purpose of this study is to test (1) the significance of relationships among e-service quality, satisfaction, trust, and purchase intention, (2) the comprasion effect of culture on e-service quality, satisfaction, trust and purchase intentions between online retailing websites of Taiwan and Malaysia.

LITERATURE REVIEWS

e-Service Quality (E-SERVQUAL)

The main purpose of running a business is to pursue a better goal and higher profits. Developed from Internet marketing and the traditional service quality literature, service quality is one of the key factors in determining the success or failure of electronic commerce (Yang, 2001). The concept of service quality in e-commerce, also called e-service quality, can

be defined as the consumers' overall evaluation and judgment of the excellence and quality of e-service offerings in the virtual marketplace. Parasuraman, Zeithaml, and Berry (PZB) (1985) developed a multidimensional service quality assessment scale known as SERVQUAL which define the term service quality as being the perception by a consumer of the difference between the expected service and perceived service such as reliability, responsiveness, competence, courtesy, communication, credibility, security, understanding, access and tangible.

Furthermore, Parasuraman et al. (1988) developed a definition of service quality as being "the overall evaluation of a specific service firm that results from comparing that firm's performance with the customer's general expectations of how firms in that industry should perform". As for e-commerce stores, a well-designed website will create a different value from the normal, and improve interest of a consumer access to the site simultaneously. Abels et al. (1999) proposed six operational definitions of user criteria for site design on library. Nevertheless, Santos (2003) used focus groups interviews to provide input for the development of the conceptual model of e-service quality. It is proposed that e-service quality consists of an incubative dimension and an active dimension using time – before and after a Web site is launched – as the criterion for separating the dimensions. A well design website will create profits and contribution to a company. E-service quality not only provides an e-commerce corporation a better advantage of competitive. It also enhances the relationship between producers and consumers through consumer quick respond to involve consumer into the process of product development. Ease of use, usefulness, appearance, linkage, structure and layout, and content will be used in this study as the e-service quality (E-SERVQUAL) that attracts consumers.

Satisfaction, trust, and purchase intention

Sysmanski and Hise (2000) summarized that convenience, product offerings and product information, site design and financial security are the antecedents of e- satisfaction by using focus-group interview. The empirical results of the study found that convenience, site design and financial security had the significance influence to e-satisfaction. Rust and Oliver (1994) suggest that customer satisfaction reflects the degree to which a consumer believes that the possession or use of a service evokes positive feelings. It is important to note that satisfaction could be further conceptualized as a transaction specific satisfaction or cumulative outcome or overall satisfaction (Kuo et al., 2009; Chang, 2005). Parasuraman et al. (1988), Cronin and Taylor (1994), and van Reil et al. (2004) consider overall satisfaction to be primarily a function of perceived service quality. Compared to transaction specific satisfaction, overall satisfaction reflects consumers' cumulative impression of a firm's service

performance. While Oliver (1981) states that satisfaction is a summary of psychological state originating when the emotion surrounding disconfirmed expectations is coupled with the consumer's prior feelings about the consumption experience.

Corritore et al. (2003) provide a definition of online trust that includes cognitive and emotional elements, with trust encompassing "an attitude of confident expectation in an online situation or risk that one's vulnerabilities will not be exploited" (Cyr, 2008). Furthermore, the design of a website to a consumer to trust and feel confidence is very important and "willingness to rely on the retailer and take actions in circumstances where such action makes the consumer vulnerable to the retailer." Cyr (2008) developed a model to examine the characteristics of culture and design including information design, visual design and navigation design as antecedents to Website trust, Website satisfaction, and e-loyalty in Canada, Germany and China. The result showed that design characteristics should be central consideration in Website design across culture.

Consumer browsing behavior will influence consumer's purchase intention and re-purchase cause from consumer's experience. Henderson, Rickwood and Roberts (1998) developed a visual online store to examine the theory of planned behavior and suggested that the purchase intention of consumers will be affected if the consumers unable to browse or access to the virtual online store at the first time. Lohse and Spiller (1998) observed 28 online stores and sorted out six categories of environmental design that attract consumers. Emphasized that the more simple and easy of user interface and the lower complexity of information will easily affect consumer's purchase intention

Culture

According to Hofstede, national culture is "the interactive aggregate of common characteristics that influence a human group's response to its environment" (Dan J. Kim, 2008). Hofstede developed an index model that identifies five primary cultural dimensions: individualism (IDV), power distance index (PDI), masculinity (MAS), uncertainty avoidance index (UAI), and long-term orientation (LTO). Although the Hofstede dimensions are the most widely used, they have been criticized for equating nation with culture and for falling short of describing all important aspects of national cultures. To enhance this present study of the effects of national culture on trust antecedents, therefore, a second dominant culture theory proposed by Hall and Hall is included. Hall and Hall differentiated "high context" and "low context" national cultures mainly focused on communication aspects, an important part of the innovation adoption process. Context refers to how individuals and their society seek information and knowledge. People from high-context cultures (e.g., Japanese,

Chinese, Italians, Latin Americans, Arabs, Africans, Koreans, Southeast Asians, etc.) obtain information from personal information networks such as friends, business acquaintances, and relatives, whereas people from low-context cultures (e.g., Swiss, Austrians, New Zealanders, South Africans, Americans, Canadians, etc.) seek information about decisions from direct information sources such as watching, reading, reports, and databases (Dan J. Kim, 2008).

Hofstede's (2003) research analysis (Table 1) showed that Taiwan has higher individualism and power distance index than Malaysia. It means Taiwan tend to be an individual actions and not centralized country. While Malaysia has higher masculine and uncertainty avoidance index than Taiwan. It means Taiwan tend to have entrepreneurship, the spirit of adventure, and need more stability on work. Furthermore, Taiwan has higher long-term orientation than Malaysia. It shows that Taiwan is a country with high persistence and it takes long-term orientation seriously and thinks time as a finite resource and thrifty.

Table 1: Statistic scores of national culture dimensions.

Country	PDI	IDV	MAS	UAI	LTO
China	80	20	66	30	87
Hong Kong	68	25	57	29	61
Japan	54	46	95	92	88
Singapore	74	20	48	8	72
South Korea	60	18	39	85	100
Taiwan	58	17	45	69	93
Malaysia	104	26	50	36	41
Phillipines	94	32	64	44	27
Vietnam	70	20	40	30	57
Thailand	64	20	34	64	32
Indonesia	78	14	46	48	62
India	77	48	56	40	51

RESEARCH DESIGN AND METHOLOGY

The research model (figure 1) is based on integration of literatures from many scholars' opinions such as the e-service quality proposed by Abels et al. (1999) and Santos (2003), and TAM model proposed by Davis (1986). Analyzed the relationship between the e-service quality provided by the online retailers, built up consumer's trust and meet the need of

consumer's satisfaction. The questionnaire used in this study was design according to related literatures and scholars' opinions. The questionnaire initially including 65 items was generated, consisting of 45 items for e-service quality, 5 items for satisfaction, trust, and purchase intention respectively. All items were assessed using seven-point Likert scales from 1 = "strongly disagree" to 7 = "strongly agree".

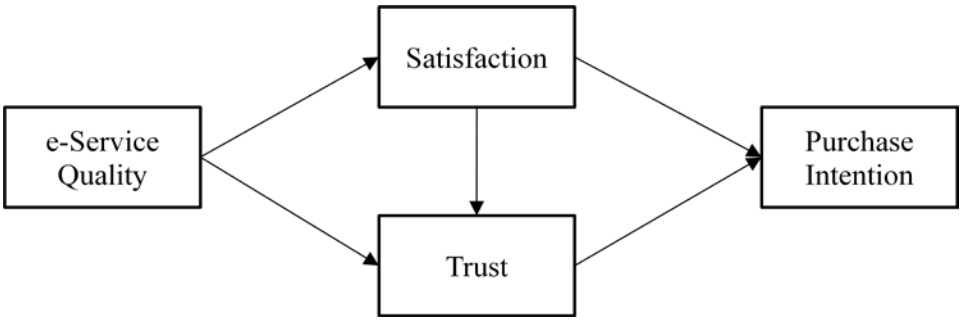

Figure 1: The research model.

The links for the online survey questionnaire were linked to Taiwan and Malaysia's infant and baby products' online store respectively. While the language used in this study was Chinese for online consumer in Taiwan and English for online consumer in Malaysia. The part of language translation was requested by the professor from the department of English application on behalf of audit grammatical errors and smoothness of the sentences.

DATA ANALYSIS AND RESULTS

Demographics of samples

The data were gathered through the internet questionnaire of Happy Home (http://www.hbhome.com.tw/front/bin/home.phtml) in Taiwan and Littlewhiz (http://www.littlewhiz.com/) in Malaysia. For the final survey, 120 survey questionnaires were collected from Taiwan respondents and 118 survey questionnaires were collected from Malaysia respondent respectively. The basic attributes of respondents are shown in this section: ethnicity, gender, age, online shopping experience since, marital status, intention of shopping online, average monthly online shopping, and average monthly online shopping expenses. In the aggregate sample for Taiwan respondent, 50.4% respondents are men and 48.8% are women. More than 60% respondents are people born between year 1980 to 1988, and most of the respondents have more than 3 years experience in online shopping. While in the aggregate sample for Malaysia respondent, 81.4% respondents are women and 18.6% are men. All of the respondents are between age 22 to 36, and most of the respondents have less then 3 years experience in online shopping.

Reliability and validity test

A Confirmatory Factor Analysis (CFA) using AMOS 6.0 was conducted to test the measurement model. Reliability and convergent validity of the constructs were estimated by composite reliability and average variance extracted (AVE) (see Table 2 and 3). The composite reliability for all constructs was above the recommended 0.70 level. Convergent validity can be assessed by the average variances extracted (AVE) and all were above the recommended 0.50 level (Fornell & Larcker, 1981), which meant that more than half of the variances observed in the items were accounted for by their hypothesis constructs. Convergent validity can also be assessed by factor loading.

According to Hair et al.'s (1992) recommendation, factor loadings level which greater than 0.50 were significant. All of the factor loadings of the items in this study were greater than 0.50 and each item loaded significantly on its underlying construct. Therefore, all constructs in the model had adequate reliability and convergent validity.

To examine discriminant validity, this study compared the shared variances between constructs with the AVE of individual constructs. Following Fornell and Larcker (1981), this can be demonstrated by the fact that the square root of AVE each construct should generally be higher than the correlations between it and any other constructs in the model. All results confirm to be discriminant validity as shown in Table 4. In summary, the measurement model demonstrated adequate reliability, convergent validity and discriminant validity.

Table 2: Confirmatory Factor Analysis (CFA) for e-service quality.

Constructs	C.R.	AVE	χ^2	DF	χ^2/DF	GFI	AGFI	RMSEA
Ease of Use	0.875	0.640	0.271	2	0.136	0.999	0.997	0.000
Usefulness	0.840	0.639	-	-	-	-	-	-
Appearance	0.875	0.641	1.246	2	0.623	0.997	0.987	0.000
Linkage	0.867	0.687	-	-	-	-	-	-
Structure and Layout	0.901	0.645	6.434	5	1.287	0.989	0.967	0.035
Content	0.892	0.674	1.234	2	0.617	0.997	0.987	0.000

*** Report analysis output from AMOS 6.0

Table 3: Confirmatory Factor Analysis (CFA) for satisfaction, trust, intention.

Research constructs	C.R.	AVE	χ^2	DF	χ^2/DF	GFI	AGFI	RMSEA
Satisfaction	0.839	0.636	-	-	-	-	-	-
Trust	0.848	0.651	-	-	-	-	-	-
Intention	0.887	0.724	-	-	-	-	-	-

*** Report analysis output from AMOS 6.0

Table 4: Discriminant validity.

		e-service quality						SAT	TRU	INTENT
		EOU	USE	APP	LINK	LAYOUT	CONT			
e-service quality	EOU	1								
	USE	0.667**	1							
	APP	0.513**	0.643**	1						
	LINK	0.445**	0.596**	0.604**	1					
	LAYOUT	0.594**	0.674**	0.678**	0.626**	1				
	CONT	0.616**	0.715**	0.625**	0.603**	0.695**	1			
SAT		0.475**	0.546**	0.561**	0.495**	0.614**	0.663**	1		
TRU		0.560**	0.577**	0.527**	0.496**	0.568**	0.635**	0.683**	1	
INTENT		0.435**	0.447**	0.413**	0.345**	0.437**	0.490**	0.594**	0.663**	1

**; p<0.01 significant

Structural equation model (SEM)

This study employed structural equation model (SEM) to verify the proposed model and used AMOS 6.0 software to analyze this model. The dimensions of e-service quality, satisfaction, trust, and purchase intention were analyzed first. Later, the research model was analyzed and verified. In the model fitness test, measurement model test and structural model test were used. To test the normality assumptions underlying the maximum likelihood procedure, multivariate normality test were used to exam whether the data were normal distributed and the result indicated that data were normal (p-value>0.05). Then the confirmatory factor analysis (CFA) was performed to test the overall fit of the measurement model. As shown in Table 2 and 3, all the squared multiple correlations (SMC) of the

measured variables were larger than 0.50. Moreover, the completely standardized factor loadings all reached the level of significance.

In the structural model, Bollen(1989) pointed out χ^2/df below 5 is considered ideal fitness and the most widely used overall model fit indices are the goodness of fit index (GFI), comparative fit index (CFI), the adjusted goodness of fit index (AGFI), the root mean residual (RMR), and the normed fix index (NFI). Threshold values for these indices are above 0.90, above 0.90, above 0.80, ranging from 0.05 to 0.08, and above 0.90, respectively (Hair et al., 1998). Another measure that attempts to correct for the tendency of the Chi-square statistic with a sufficiently large model is the root mean square error of approximation (RMSEA), where values ranging from 0.05 to 0.08 are deemed acceptable (Jarvenpaa et al., 2000; Byrne, 2001). In this study, values of GFI, AGFI, CFI, and RMSEA are 0.572, 0.539, 0.777 and 0.080, respectively and value ofχ^2 and df (degree of freedom) is 2446.622 and 981, respectively. Meanwhile, χ^2/df is 2.494 falling within the recommended ranges.

Figure 2 and 3 show the estimated path coefficients of the structural equation model for Taiwan and Malaysia respectively. The result of this study shows that consumers in Malaysia are more concern about the performance on e-service quality of e-retailers than consumers in Taiwan. That is because of consumers in Taiwan have more experience in online shopping than consumers in Malaysia. The results in figure 2 and 3 seem to indicate that the interrelationships among e-service quality, satisfaction, trust, and purchase intention are specifically significant except for the relationships between satisfaction and purchase intention in figure 3 shows insignificant.

From above analysis, culture dimension will be used to explain the different online purchase behaiver between Taiwan and Malaysia. According to formula given from Hofstede's present studies is only uncertainty avoidance index adopted in this study. Based on Hofstede's culture dimensions, the online purchase intention of consumers is deeply affectd by different construct which is satisfaction and trust because of the different uncertainty avoidance index in the different countries.

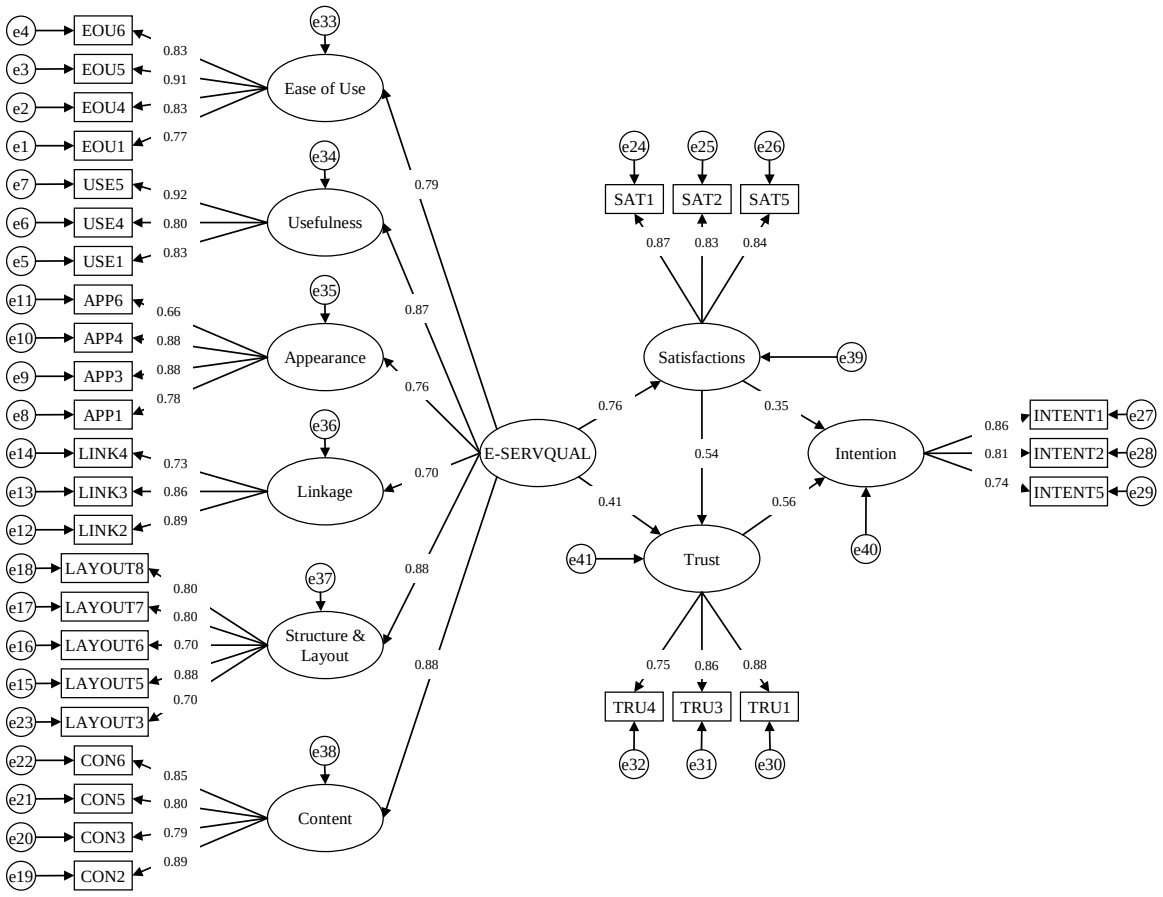

Figure 2: Taiwan's SEM model.

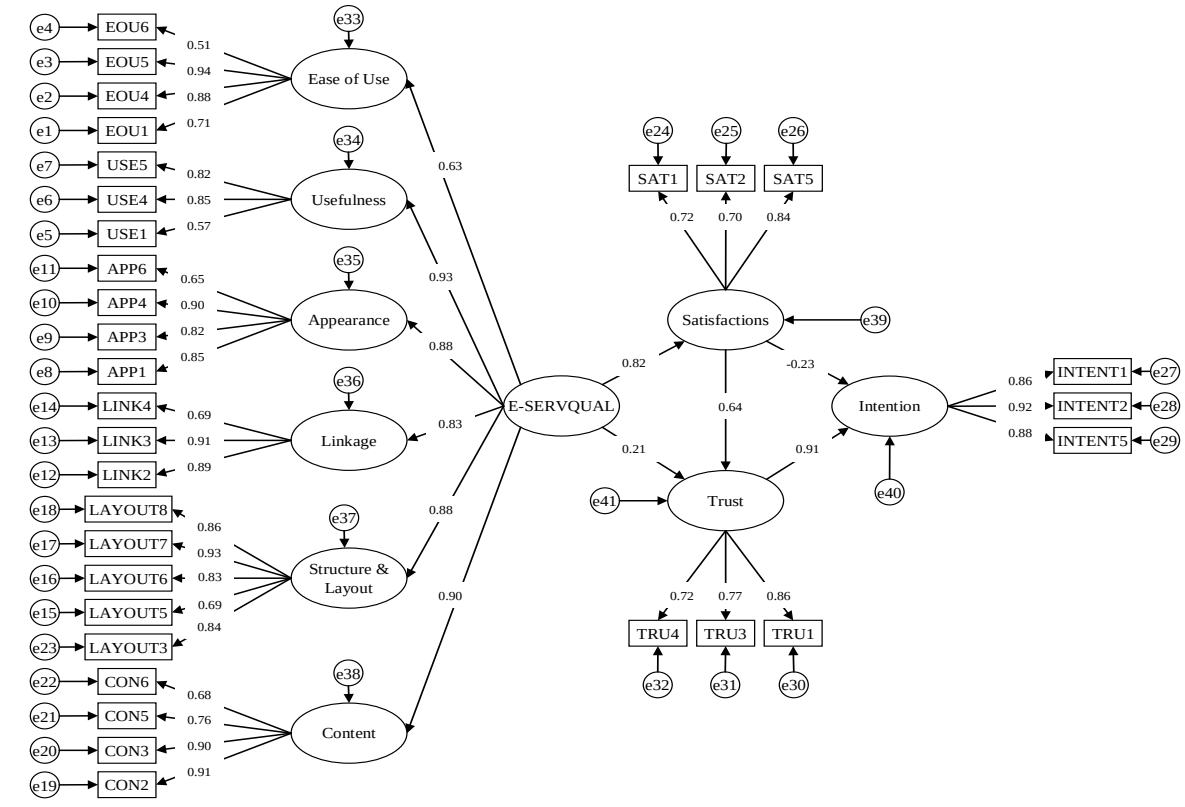

Figure 3: Malaysia's SEM model.

CONCLUSIONS

The major objectives of this study were to identify the interrelationships among e-service quality, satisfaction, trust, and purchase intention on the online retailing websites. Interestingly the SEM model between Taiwan and Malaysia are significantly different as shown in figure 2 and 3. As shown in figure 2, e-service quality of Taiwan model has significant effects on satisfaction and trust. While on the other hand, e-service quailty of Malaysia model has significant effects on satisfaction but not for trust.

For online consumers in Taiwan, purchase intention will be affected by satisfaction and trust of the website. However, as the network speed and experience in online shopping for consumer in Malaysia is not as high as compare to Taiwan. Purchase intention will not be affected by satisfaction but with the trust of the website. According to Hofstede's culture research, we found that Malaysia is a low uncertainty avoidance country while Taiwan is a moderate uncertainty avoidance country.

From the managerial implications, the e-retailers must take consumers' satisfaction and trust into consideration will be more effective than the advertising or worth of mouth. Avoid overly complicated of website design or need good quality of network for opening the website smoothly. Moreover, it will enhance the opportunity for consumer to shop at the website if the e-retail makes consumers feel reliable and comfortable when they first entered. As the age and the experience of shopping online are different between Taiwan and Malaysia, therefore it is important for e-retailers to provide a good service quality in order to enhance consumers' satisfaction and trust.

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B2 – Product life-cycle management

B2.1 **A framework for improving the launch concept of new services**
Risto Silvola

B2.2 **An application of response surface methodology on accelerated life testing plan**
Dr. Chau-Chen Torng

B2.3 **Different intensity of interfirm collaboration in open business model: a study of Taiwanese convenience store industry**
Kuo-Nan Hsieh

B2.4 **Elements and implementation of product data ownership network**
Risto Silvola

B2.5 **Lifecycle view on product data quality dimensions**
Olli Jääskeläinen

A FRAMEWORK FOR IMPROVING THE LAUNCH CONCEPT OF NEW SERVICES

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ABSTRACT

The purpose of this study is to enhance the current understanding about the new service launch process within telecom service industry. Further, the study examines the process improvements that product data management could offer in this context. This research utilised literature and case studies. The case company was chosen to present telecom service industry where well controlled launches have not always been the convention. Data collection was carried out through workshops and interviews. Product process and product/service launch process cannot be separated from each other. To secure full benefits from the launch, the whole service lifecycle has to be taken into account. Service businesses frequently lack rigorous development processes with defined milestones and checklists. Structured design methods, for instance particular perspective emphasising "Design for X", would bring value to the new service development and hence to launch. This is an exploratory research where literature offers only scattered knowledge regarding new service development (NSD), data management and especially the studied industry lacks defined best practices. However, the results provide a good view of what these could be. Elements and best practices of product data management (PDM) for the new service launch process within the case industry are worth further studying. Finally, all these measures improve the customer experience, time to market and the efficiency of development efforts. This study suggests that there are benefits in linking PDM and NSD process. Further research in this field is needed as both academic and industry practitioners are still missing the general view in telecom services.

Keywords: Product data, product launch, service launch, new service development, telecom service

INTRODUCTION

The deregulation of telecommunication services has altered competition and directed dissolving monopolies to develop and launch innovative services as they are exposed to

increasing pressure from software and content industries. Due to their background and owing to the customs of the service sector, telecommunication service providers have been developing new services through quite ad hoc and free-floating procedures. The typical ease of new service development has frequently led to the proliferation of product variants and unnecessary changes to customers and internal functions. (Kelly and Storey, 2000; Magnusson et al., 2003; Gallouj and Weinstein, 1997; De Jong et al., 2003; Allee and Taug, 2006.)

The launch as the final phase of New Product or Service Development (NPD & NSD) pursues to maximise the success of new products by promoting market acceptance (Guiltinan, 1999). The studies on launch are minuscule compared with the front end of NPD (Di Benedetto, 1999). Formal processes over the back end of NPD have still been perceived to contribute to new service success (De Brentani, 2001).

Increasingly sophisticated customer requirements necessitate a wider variety of offering and hence more delicate NPD to battle the development complexity and avoid introducing outdated products. Managing development duration, cost and quality demands cooperation between numerous teams which create and utilise product knowledge in multiple distant locations. Such NPD calls for product lifecycle management (PLM) to integrate different processes and their agents through a shared body of knowledge. (Ameri and Dutta, 2005). The effective sharing and utilisation of product data are necessary for enabling rapid product launches (Ouertani, 2010; Huang et al., 2004; Sulaiman, 2000; Philpotts, 1996). Effectiveness within product data management (PDM) calls for a unified schema to be used in electric data transfer (Saaksvuori and Immonen, 2008).

Within the early new product development, there should be guidelines regarding how to ensure that unnecessary changes to the supporting applications are not made. In telecom service context, these applications are called operation and business support systems (OSS/BSS) and include, among others, service activation, billing and service assurance (Tyrvainen and Frank, 2008). It is vital to plan and understand well prior to launch the behaviour of the new service within the delivery supply chain. This allows IT tools capability to be analysed and scoped according to the delivery volumes and specialities. Key questions derive from the peculiarities of telecom service business such as the billing and delivery/provision volume forecasts; service item maturity, network capacity monitoring, and application upgrade complexity. Processes within the operator business are highly automated and require data form multiple sources. This implies that well managed and structured data is fundamentally required to deliver the value promised to the customer.

The purpose of this study is to identify the gap between current and ideal states in the product process for new services that proceed to be launched within the case company in telecom service business. Current literature and practice have several approaches on launch execution. Examples of these viewpoints include new product/service development, productization, design for X and product data (what information and when? How is it maintained?). Product launch and product data management are not linked in the current literature. Therefore we have compressed our target to following research questions:

RQ1. How to internally secure that new services are successfully launched?

RQ2. How does currently the case company manage its new service launches especially regarding the internal stakeholders?
RQ3. How should the case company ideally launch its new services?

The first question has theoretical content with practical relevance compiled in the end of literature review. Second question follows the problem setup in case company and thirdly, a framework for improved launch management utilising PDM will be conceptualised. More accurate development process has been presented in research process description.

LITERATURE REVIEW: LAUNCHING NEW SERVICES SUCCESSFULLY

One cannot capture the meaning of services within a single definition because the range of services and service features is vast (Cook et al., 1999; Johnston and Clark, 2008). The term service product denotes the composite of service experience and service results (Johnston and Clark, 2008). One major distinction between goods and services is that the service is consumed during its production (De Brentani, 1991; Johne and Storey, 1998; Lenfle and Midler, 2009). Services are processes that occur either as a one-time performance or within a contract based customer relationship (Tiihonen et al., 2006). Grönroos (1990) manages to define the service by staying universal:

> [Service is] an activity or series of activities of more or less intangible nature that normally, but not necessarily, take place in interactions between the customer and service employees, and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems.

Services can be divided in the terms of amount of interaction between the service provider and the customer (Goldstein et al., 2002). Vargo and Lusch suggest that "*goods are distribution mechanisms for service provision*", which signifies that every firm fundamentally serves its customers. I.e. "*goods derive their value through use - the service they provide.*" (Vargo and Lusch, 2004; Vargo and Lusch 2008).

The NSD literature favours the term *service concept* (Figure 1) to denote the expectations of customers and service providers on the service and customer needs. The service concept offers the foundations for the marketing content (*What?*) and operations content (*How?*) (Goldstein et al., 2002). According to Johnston and Clark (2008), the elements of a service concept are the direct *service experience* of the customer, *the results and the benefits of service* for the customer, *service operations* by which the service is delivered to the customer and *the value of service* which denotes the ratio of benefits to price. The service concept is closely related to the productization philosophy that is presented next.

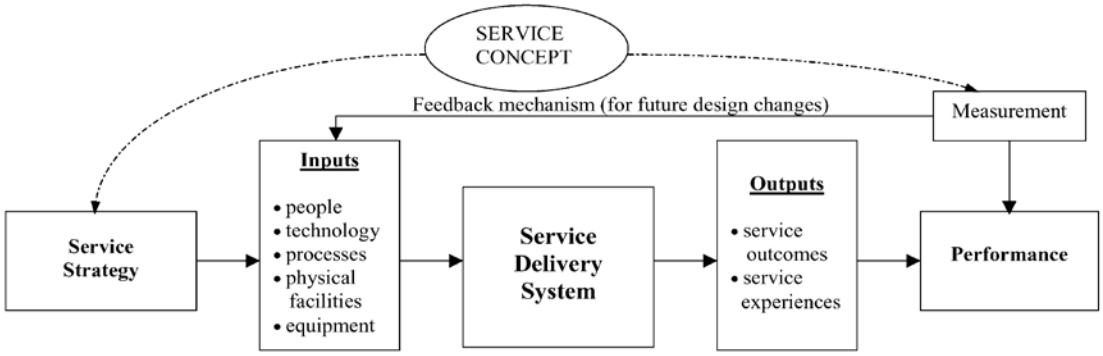

Figure 1: Concept based service design planning model (Goldstein et al., 2002).

Productization is a practical concept to support the communication between marketing and design people over the product development. The main idea behind productization is that after the company has fulfilled the basic NPD goal of importing well designed products into the supply system, it still has to seek means of selling them profitably. Internally this means matching the offering to the operations to improve efficiency. Marketing-wise, productization means building a more appealing offering. (Simula et al., 2008).

New Product Development Process

A closely defined and repeatable NPD process has been perceived as a significant success factor within the management of product and service development projects. This does not mean converting the existing ways of working into business process documentation but improving the methods conformable to best practices. (Cooper, 1996; Froehle et al., 2000.) Research within the field of NPD mostly agrees that the NPD process consists of series of development stages and evaluation gates (Tzokas et al., 2004).

Earlier NSD research proves that time and quality problems within service design are partly caused by the industry standard of weakly determined development methods (Gallou and Weinstein, 1997; Johne and Storey, 1998; De Jong et al., 2003; Dolfsma, 2004; Lenfle and Midler, 2009). De Jong and Vermeulen (2003) emphasise that service innovations are not frequently related to technology as great potential for advancements in services lies in service concepts, customer interfaces and delivery systems. Capacity creation and ramp up are suitable examples of tasks that more frequently extend NPD projects than NSD projects (Crawford and Di Benedetto, 2000.) Service development is thus possibly more effortless but also more common than the development of physical constructs. Yet Johne and Storey (1998) underline that the simultaneity of service production and consumption create demand for capacity planning as services cannot be held in stock. The frequently rapid development of service innovations allows services to be imitated very swiftly. Furthermore, the ease of implementing innovations may cause inadequate evaluations regarding the effects of new service features. (Voss, 1992; Johne and Storey, 1998). The intangible nature of services causes a need to 'tangibilise' the service concept so that it is not too abstract to be understood in consistent fashion (Menor et al., 2002).

It is clear that no modelling of the real NPD processes can be more than a crude estimation on the phenomenon. (Krishnan and Ulrich, 2001). Researchers have recognised two macro phases within NPD-projects i.e. "*the fuzzy front-end*" and "*the execution-oriented back-end*"

(Menor et al., 2002) or definition phase and realisation phase (Kalyanaram and Krishnan, 1997). At the early evaluations (gates) the projects are frequently measured against quite qualitative "*must have*" and "*should have*" criteria. As the project proceeds to the potential launch and starts to occupy more and more resources and stakes, the criteria gain respectively more financial and quantitatively reasoned profitability orientation. (Cooper, 1990). Further, the mortality rate of projects decreases as they proceed to launch (Barczak et al., 2009).

Consequently, the generic NSD model trying to describe the development processes has to be simplified as service provision forms an even more diverse group of industries than the manufacture of goods. The aforementioned two development phases provide enough precision. Here, these phases are named as search and implementation (Figure 2.) In the search phase, every idea would be treated as a promising opportunity for improved profits and ideal developer mindset would be creative and capable of sound decisions. The activities within the course of the search stage consist for instance of strategic positioning, idea generation and concept development and refinement. Over the implementation phase, the most promising ideas are converted to qualify being put up for sale. There creativity must yield to result orientation as the actual elements of the service delivery are adapted from prior capabilities, developed or outsourced. (Menor et al., 2002; De Jong et al., 2003.) Kuusisto and Riepula (2007) add that different phases of NSD should be considered parallel activities that vary in intensity as too much sequencing is artificial.

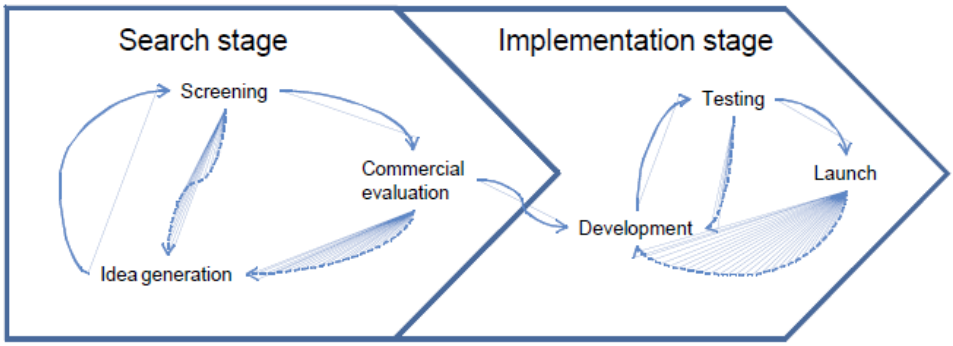

Figure 2 : NSD process model (de Jong et al., 2003).

Some design methodologies rooted in mechanical design, for instance, are general enough to be utilised in NSD processes. Tomiyama et al. (2009) highlighted a couple of concrete and general design methods on their design methodology keynote paper. These methods included Design for X (DfX) that focuses on concrete design goals within design and concurrent engineering which concentrates on design process management. For example, Menor et al. (2002) designate the optimization of service delivery as DfI (*Design for Implementation*).

Service Lifecycles

Service provisions frequently have a legal or social contract based warranty for extended periods of time. The warranty implies or expresses the promise that the exchange relationship will yield valuable service provision. Breaking the social warranty of service provision has "only" service provider's brand and customer relations at stake, but legal

contract may be the sole determinant of the conditions under which the life of the service may end. The service guarantee represents one type of *Quality of Service* (QoS) warranties which can be formalised in *Service Level Agreements* (SLA) (Vargo and Lusch, 2004; Voss, 1992; Dumas et al., 2003.) Provision of a service can for instance in mobile telephony be initiated and discontinued by a self-serving customer. Nevertheless, telecom operators rely mostly on their old rigid business and provision models. (Yelmo et al., 2007).

Product Data and Lifecycle Management

Product data is defined here as the type of data that is related to the product (Kropsu-Vehkapera et al., 2010). Product data is divided into product definition data, product lifecycle data and metadata. (Saaksvuori and Immonen, 2008). Two first-mentioned product data types can embrace both static and dynamic data. Static data comprises the information regarding product composition and processing. Static data can be relatively effortlessly captured into a PDM system. The task of keeping dynamic product data up to date is more laborious because it consists of events related to the product. (Yang et al., 2007.)

PDM helps companies to operate more effectively and efficiently. (Stark, 2005). Its most important task is to secure the availability of accurate product data (Kropsu-Vehkapera et al., 2009). PDM can be seen as an integration tool that delivers accurate product data in desired format timely to those in need of it (Liu and Xu, 2001). Subrahmanian et al. (2005) advise that PDM should engage in product information and even knowledge exchange to enable a PLM support system. Liu and Xu (2001) collected a summary of PDM benefits in the following topics: interdisciplinary collaboration, reduced time to market, reduced complexity of assessing the data of a company, improved project management, improved life cycle design (Design for X) and supply chain collaboration. Ameri and Dutta (2005) describe PLM as a knowledge management system that supports various lifecycle processes. PDM systems tend to be focused on certain aspects of lifecycle, typically design and manufacture. As a process, PLM incorporates larger scope as it supports the capture, organisation and reuse of knowledge through the product lifecycle.

Service Launch Success Factors

Process modelling improves development outcome quality. Further benefits are gained indirectly when the model reduces the impact of development task uncertainty on the quality of development. (Rai and Al-Hindi, 2000.) Di Benedetto (1999) observed both strategic and tactical launch management and discovered many activities that were well executed in successful launches (Table 1). The table also includes results from two other studies that are explained below.

Table 1: The most important determinants of new product performance (Di Benedetto, 1999; Voss 1992; Hultink and Robben, 1999).

Strategic Launch Activities	• Cross-functional teams make decisions concerning operations and marketing/sales strategy • Involving logistics in distribution strategy formulation, sales management coordination, inventory strategy development and after-sale service. • Decision to launch an innovative new product that belongs to the primary offering • A broad offering to cover varying preferences and budgets • Aiming to enter new or expand current high growth markets • Capitalising on the firm's or another brand's reputation, thus assuring broad acceptance • Fit with financial resources, sales and marketing capabilities, market research capabilities, existing delivery system, human resources, and managerial skills and preferences. • Formal post-launch evaluation
Tactical Launch Activities	• High quality of selling effort, advertising and technical support. • Well managed launch key activities (marketing plans, overall launch direction, launch itself, explicit market penetration objectives when launching to an existing market) • Well managed support programs (distribution channel activities, sales force training, appropriate pricing level, advertising program execution) • (Early) launch timing relative to competition and customers. Further, short NSD lead time • Penetration pricing • Project champion during launch • Securing resource availability • Full testing before release • Good cross-functional communications
Market Information Gathering Activities	• Phased market testing (customer selection, submitting the products to test customers, test market execution and analysis) • Studying customer feedback both during and after launch • Planning and testing advertising • Outsourcing specialised research work. • Explicit awareness of competitors' reactions to the launch. These reactions are visible to all market parties but are naturally uncontrollable by the manager introducing a new product. This needs to be set off against the clarity of the type and intensity of the reactions from competitors.

Hultink and Robben (1999) examined the relation between launch strategy and market characteristics, and new product performance. Overall, tactical activities were better managed, whereas strategic groundwork is frequently omitted in less successful launches (Di Benedetto, 1999). Voss (1992) studied performance under the service design and innovation topic, but found many similar results that fit under the launch topic.

2003 PDMA Best Practices Study proved that numerous overall NPD management methods at various levels are more widely used in the best companies than at the rest (Table 2). Further, no single practice was found to be either sufficient or necessary to guarantee the company's superiority in new products. (Barczak et al., 2009.)

Table 2: Most utilised NPD tools (most common first) (Barczak et al., 2009).

Market Research Tools	Engineering R&D and Design Tools	Technology Tools - Most utilised	Team Support Tools
• Beta testing	• DfM	• CAD/CAE	• Face-to face meetings
• Customer site visits	• Concurrent engineering	• Project management systems	• Teleconferencing
• Voice of the customer	• Failure mode effect analysis	• Document management systems	• Critical path, PERT, GANTT
• Alpha testing	• Value analysis	• Rapid prototyping systems	• Dedicated project intranet
• Lead users	• Quality function deployment	• PDM systems	• Team co-location
• Concept tests	• Six sigma analysis	• Performance modelling & simulation	• Videoconferencing
• Focus groups		• Resource management systems	• Groupware
• Gamma testing			• Team-building exercises
• Ethnography			• Interlocking teams
			• Parallel development

NPD Success Measures

Voss (1992) proposes that [service] innovations can be measured in two dimensions. These measures are the result of the NPD project and the determinants of success in the NPD process. Latter measures were discussed above under the success factors topic. Table 3 demonstrates some measures against which the development results can be evaluated.

Table 3: Examples of measures of the results of service innovation (Voss, 1992).

Financial Measures	Competitiveness Measures	Quality Measures
• Achieving high overall profitability	• Exceeding market share objectives	• Great realisability
• Substantially lowering costs for the firm	• Exceeding sales/customer use level objectives	• More user-friendly
• Performing below expected costs	• Exceeding sales/customer use growth objectives	• Resulting in superior service outcome to competitors
• Achieving important cost efficiencies for the firm	• Having a strong positive impact on company image/reputation	• Resulting in superior service experience to competitors
	• Giving the company important competitive advantage	• Having unique benefits, perceived as superior to competitors
	• Enhanced sales/customer use of other offering	
	• Achieving high relative market share	

Generally, successful development results emerge from successful development processes. Table 4 summarises some of these process measures. The development process should adjust to various development aims as, for example, strict conformance to process specifications can hinder innovativeness while it is certainly useful in more straightforward NSD projects (Voss, 1992).

Table 4: Measures of the process of innovation (Voss, 1992).

Criterion cost	Effectiveness	Speed
• Average development cost per service product	• How many new services developed annually	• Concept to launch time
• Development cost of individual service product	• Percentage new services that are successful	• Concept to prototype time
• Percentage of turnover spent on developing new services, products and processes		• Prototype to launch time
		• Time to adopt new concept from outside the firm

Di Benedetto (1999) measured new product success against overall profitability and profitability, revenue and market share in relation to the competition. According to Tzokas et al. (2004), the literature examining new product success tends to focus on post-launch

performance and omits to address how well the NPD project management and evaluation attain certain performance results.

The Cornerstones of New Telecom Service Launch Readiness

The literature review suggests that decent data management practices can substantially benefit the performances of the service launch process and the launched services. The latest PDMA study confirms that PDM systems are among the most utilized NPD tools (Barczak et al., 2009.) Stark (2005) and Philpotts (1996) argue that PLM or PDM is a necessary enabler of concurrent engineering practices.

Services possess some characteristic attributes that certainly need to be taken into account before launching the service publicly. Recalling a contract based service once it is delivered may pose difficulties. The provider may be stuck to provide low usage and low profit services for a long period (Voss, 1992). Further, Eul et al. (2010) suggest that complexity of services and product portfolio is the most significant external IT cost driver in telecom services. They argue that the complexity should be managed by fact-based and business case driven demand management, and lifecycle management focusing on cleaning the product portfolio. The latter may be strongly dependent on the decisions made before launch. The often substantial provision volumes in telecom services necessitate that the efficiency level of the service delivery system is considered closely. Generally, this means reducing the share of manual provision labour as the volumes grow. Internal productization and design for X, X denoting e.g. implementation or end-of-life, are among the concepts that would assist these efforts.

RESEARCH METHODOLOGY

This study was conducted as a qualitative single case study. The study is of exploratory nature which implies that it aims to generate research questions that are worth further research (Voss et al., 2002). Figure 3 illustrates the research process applied in this study.

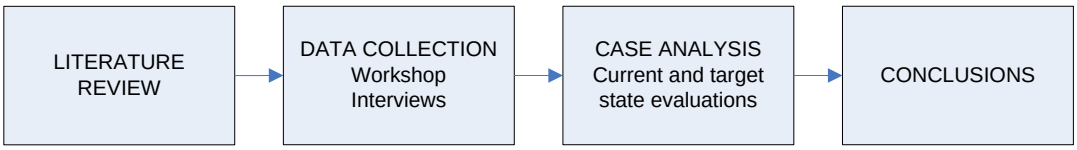

Figure 3: The Research Process.

RQ 1 is answered by summarising the potential benefits of service modelling and PDM to the new services. This is supported by the current state analysis of the case company. First empirical section aims to map the topical service implementation problems through a workshop where experts who face the challenges in daily life are collected from various organisations and. Experts are also asked to describe what development and implementation activities they find deficient. Further, the workshop builds a basis for the ideal service launch/implementation model. This is based on the identified best practises from the literature and completed by interviewing selected professionals from various functions of the case company.

The case company was purposefully selected to present the telecom service industry. The aim is to address the theoretical gap that exists in NSD data management in the selected industry setting (Eisenhardt, 1989.) The execution oriented back-end preceding the publication of new service is the unit of analysis and is here referred to as the launch phase. The study also examines the earlier NPD management as the antecedent of a successful launch. Here the product launch process is observed separately from technology life cycles. This distinction should be understood much better even tough it is not a driver in the launch phase.

The case company provides diverse telecom services. The range of services covers both mobile and fixed line connections, ICT services, outsourcing, and consultancy. Sales channels include both click and brick stores, which offer also supplementary communication device retail services. The company provides very high volume consumer subscriptions, customised unique deliveries for large corporate customers and everything in between with regard to service variety and customer contact intensity. This diversity definitely challenges NPD management, since any efforts to create common management concepts needs to take the very wide range of developmental needs into consideration.

The roots of the case company lie in tele- and data communications operator business but it is increasingly offering sophisticated information and expert services that cannot be configured and launched as swiftly as marketing department can prepare campaigns. The new service releases have to be of good perceived quality to further escape the pure price competition that the plain vanilla communications / subscriber connection business has recently featured.

The data was collected from a workshop of 24 employee participants and unstructured interviews *(and to lesser extent from personal observation, informal conversations and attendance at meetings)*. The workshop provided initial understanding about the current state of launch management in the case company and then outlined the ideal feasible state that would cure the current defects. The validity of this study was increased by using several data sources to the same questions (triangulation). In addition, theoretical orientation and assumptions were briefly clarified prior to the workshop to reduce bias. Based on the literature compilation of successful new service launch and practical challenges a list of practical requirements for telecom service launch is outlined (target stage).

NEW SERVICE LAUNCHES IN THE CASE COMPANY: CURRENT ISSUES AND PERCEIVED DEVELOPMENT TARGETS

Current State Analysis

The results in table 5 show that the cooperation between the new service development and operative organisational units should begin earlier and be stronger. A common process is missing and the progress of the development project is not visible to every stakeholder. Information regarding the product / service is available too late and is not validated by the stakeholders / data owners that are involved within the service after the commercial launch. The information here covers product / service data, product information reporting-specific data and all product documents that are required to sell, deliver, bill and maintain services.

In some cases, communication and training regarding the new service internally take place too late. This depends on time to market pressure and the magnitude of NSD. Generally, the training material is available but it does not reach every necessary stakeholder.

Measurement of the new service and its development process performance is performed but it is not standardised. This results from missing shared processes. The variance of development project magnitude ranges from service versioning to totally new service families and platforms.

Table 5: Detailed list of challenges of service launch process.

Business Organisation	Process challenges	Data challenges	Measurement challenges
New service development	• Visibility of customer expectations • Stakeholder involvement and communications • Product documentation availability prior to launch	• Product data availability • Information for e.g. product structure and reporting	• Documentation criteria and checklists • Attractiveness
Sales & Marketing	• Service maturity criteria to launch • Billing and pricing support • Training too late • Offer type definition	• Service maturity criteria to launch	• Service maturity criteria to launch • Checklist for front office training coverage
Delivery	• R&D cooperation • Extra work prior to launch to ensure delivery capability • Insufficient automation levels	• several iterations to ensure precise data cause additional costs	• Time measures for delivery subprocesses and launch subphases • Measures for service recovery (time to recovery. number of complaints and faults)
Support	• R&D cooperation • Help desk needs Preparation	• NPV data availability and reliability	• Help desk calls per number of sold services • Multiple formats of reporting

Target State

The summary of the target state discussion is presented in table 6. In the target state, all requirements of various stakeholders are recognised and documented prior to new service implementation. The best practice to pilot here could be the DfX concept. The product process supporting the whole product lifecycle and describing the dependencies and integrations between various organisation units and other stakeholders is in place and understood by all company employees. The process is supported by various milestones, checklists and audits. NSD projects are cross-functional across the enterprise. The balance between time to market and meeting the expected maturity of the service and the defined customer expectations is being monitored. New roles, for example delivery capability manager, are needed to realise the cooperation within the practical level.

Table 6: Surfaced long term development targets for service launch process.

Business Organisation	Ideal Processes	Data Management	Measurement
New service development	• Enterprise level new service development process described with roles and responsibilities • Early involvement of stakeholders	• Product lifecycle states defined • Structured information for products and reporting created and in use	• Milestone checklists and auditing
Sales & Marketing	• Development cooperation responsibilities defined		• Concurrent development of marketing and sales capabilities
Delivery	• Development cooperation responsibilities defined • Automation level optimisation according to volume forecasts	• Data quality ensured prior to launch • Data ownership handover ensured prior to launch	
Support	• Development cooperation responsibilities defined	• Data quality ensured prior to launch	• Business reporting capability ensured prior to launch

CONCLUSIONS

PLM/PDM related topics and product process development have started their breakthrough within the telecom service business over the recent years. The industry still lacks best practices in these areas whereas the manufacturing industries have well defined data management and product development processes that have evolved into an extensive solution where supporting applications and data models can be easily configured and implemented. The practices of goods manufacture cannot be directly adapted to the telecom service business as the latter involves some unique challenges. For example, the billing and order delivery of high volume services is of several complexity. NSD can be extremely agile modular product packaging or long-span platform innovations. The ideal NSD process for the case company could be relatively flexible. The best practices can only be considered once the current state has been analysed and the process development targets are accepted and piloted with measured benefits.

The greatest challenge within improving the product process is the change resistance across the enterprise. This is the reason to ensure top management sponsorship as it is the essential driver of change from the beginning. The telecom operators have typically been quick in adapting new concepts. The best practices considered based on the study could be the end to end product process with PLM and PDM coverage, DfX concept where delivery capability management is in the key position and the measurement at certain milestones is possible. The challenge here is not to lose the agility of bringing new services to the market but to conduct the launch more cost-efficiently while ensuring the product maturity to meet the customer expectations.

The study shows the need of further research within the area of lean product processes which support the above mentioned industry specific requirements. The discovery of best practices calls for close cooperation between academic and practical participants.

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AN APPLICATION OF RESPONSE SURFACE METHODOLOGY ON ACCELERATED LIFE TESTING PLAN

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ABSTRACT

Accelerated life testing (ALT) is an important approach to collect the lifetime data of products. To carry out ALT always requires longer testing time and expends higher cost. A faultless testing plan can reduce the time and cost. Response surface methodology (RSM) uses two-leve factorial designs to collect the observations efficiently. In the past literatures of ALT, the life-stress relationship models always disregarded the influence of stress interaction terms on lifetime. In fact, stress interaction terms may heavily influence the lifetime of products, and the application of RSM can analyzes this influence. In this research, experimental design is considered to plan the multiple-stress ALT and a polynomial regression model is used to fit the life-stress relationship model. Then, maximum likelihood estimation method (MLE) can be used to estimate parameters for the assumed lifetime distributions - Weibull distribution or the Log-normal distribution. An example is also provided to demonstrate the proposed methodology.

Keywords: Accelerated life testing, Life-stress relationship, Response surface methodology, Factorial design, Maximum likelihood estimation

INTRODUCTION

Many electronic parts are expected to have very long life. Accelerated life testing (ALT) is a proactive way of obtaining product failure information within a reasonable time frame. In ALT products are tested under stresses, such as temperature, voltage, humidity, load cycles per unit time, etc., that are much more severe than in a normal-use condition. The testing can be used not only for predicting product's reliability but also studying the effects of various stress variables on product's lifetime (Nelson, 1990; Meeker and Escobar, 1998). Design and analysis of accelerated life tests involve stress and stress level selection, sample size and testing time determination, allocation of testing units, and handling censored

failure time data, etc. It is typically more complicated than a traditional design of experiments (DOE).

Most of the previous work on designing ALT plan is focused on the application of a single stress. However, as components or products become more reliable due to technological advances, it becomes more difficult to obtain a significant amount of failure data within a reasonable amount of time using single stress only. Multiple-stresses ALTs have been employed as a means of overcoming such difficulties. Weis et al. (1988) employ two stresses to estimate the lifetime of silicon photodetectors.

Unlike the case of the single stress ALT, little work has been done on designing multiple-stresses accelerated life testing plans. Escobar and Meeker (1995) develop statistically optimal and practical plans with two stresses with no interaction between them. Park and Yum (1996) develop ALT plans in which two stresses are employed with possible interaction between them. The lifetime distribution of test units is assumed to be exponential. Elsayed and Zhang (2007) design two-stress ALT plans based on the proportional hazards (PH) model. No assumptions about the failure time distribution of the test units are made and the plans are optimized such that the variance of the reliability prediction is minimized. Guo and Pan (2007) formulate the D-optimal design for two-stress ALTs with Lognormal failure time distribution.

In this study, we develop the RSM-based life-stress models for multiple-stresses ALT by assuming a linear relationship between the life (response) and the stresses (design factors). The lifetime distribution of test units is assumed to be either a Weibull distribution or a Lognormal distribution. The model parameters are estimated by the Maximum Likelihood Estimation (MLE) technique. In the following sections, the approaches of life-stress model development and the parameters estimation are introduced. An example with simulation of right-censored failure data is also given.

ACCELERATED LIFE MODEL AND PARAMETERE ESTIMATION

In an effective quantitative accelerated life test, the practitioner chooses one or more stress types that cause the product to fail under normal use conditions. Stress types can include temperature, voltage, humidity, vibration or any other stress that directly affects the life of the product. For example, if a product normally operates at 290K and high temperatures cause the product to fail more quickly, then the accelerated life test for the product may involve testing the product at 310K, 320K and 330K in order to stimulate the units under test to fail more quickly.

Accelerated life model

Using the life data obtained at each accelerated stress level, we can use standard life data analysis techniques to estimate the parameters for the lifetime distribution that best fits the data at each stress level (*e.g.* Weibull or Lognormal). This results in an overstress failure density function for each accelerated stress level. Another mathematical model, the life-stress relationship, is then required to estimate the failure density function at the normal use stress level based on the characteristics of the failure density functions at each accelerated stress level. The practitioner must choose a life-stress relationship that fits the type of data being analyzed. Available life-stress relationships include the Arrhenius, Eyring and inverse power law models.

Arrhenius model

The Arrhenius life-stress model (or relationship) is probably the most common life-stress relationship utilized in accelerated life testing. It has been widely used when the stimulus or acceleration variable (or stress) is thermal (*i.e.* temperature). It is derived from the Arrhenius reaction rate equation proposed by the Swedish physical chemist Svandte Arrhenius in 1887. The Arrhenius reaction rate equation is given by:

$$R(T) = Ae^{-\frac{E_A}{K \cdot T}} \qquad (1)$$

where *R* is the speed of reaction, *A* is an unknown nonthermal constant, E_A is the activation energy (*eV*), *K* is the Boltzman's constant , and *T* is the absolute temperature (Kelvin).
The Arrhenius life-stress model is formulated by assuming that life is proportional to the inverse reaction rate of the process, thus the Arrhenius life-stress relationship is given by:

$$L(V) = Ce^{\frac{B}{V}} \qquad (2)$$

Arrhenius-Weibull model

Statisticians and engineers have developed life-stress relationship models that allow the analyst to extrapolate a use level probability density function from life data obtained at increased stress levels. These models describe the path of a particular life characteristic of the distribution from one stress level to another. The life characteristic can be any life measure expressed as a function of stress. For the Weibull distribution, the scale parameter

(η) is considered to be stress-dependent. Therefore, the life-stress model for data that fits the Weibull distribution is assigned to η.

The probability density function (*pdf*) for a Weibull distribution is given by:

$$f(t) = \frac{\beta}{\eta}\left(\frac{t}{\eta}\right)^{\beta-1} e^{-\left(\frac{t}{\eta}\right)^{\beta}} \tag{3}$$

The scale parameter (or characteristic life) of the Weibull distribution is η. The Arrhenius-Weibull model *pdf* can then be obtained by setting $\eta = L(V)$ in Eq. (4).

$$\eta = L(V) = C \cdot e^{\frac{B}{V}} \tag{4}$$

and substituting for η in Eq. (3),

$$f(t,V) = \frac{\beta}{C \cdot e^{\frac{B}{V}}}\left(\frac{t}{C \cdot e^{\frac{B}{V}}}\right)^{\beta-1} e^{-\left(\frac{t}{C \cdot e^{\frac{B}{V}}}\right)^{\beta}} \tag{5}$$

RSM-based life-stress models

RSM is a powerful technique for testing multiple process variables because fewer experimental trials are needed compared to the study of one variable at a time. Also, interactions between variables can be identified and quantified by such a technique.

The prediction equation for a two-factor linear main effect model with interaction takes the form

$$y = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_1 x_2 \tag{6}$$

where y is the response, b_0 is the y-axis intercept, and (b_1,b_2,b_3) are the coefficients of the factors. These model parameters can be estimated by the Maximum Likelihood Estimation (MLE) technique.

To develop the life-stress model for the Weibull distribution (ARL-Weibull model), we set $\eta = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_1 x_2$ and substitute for η in Eq. (3) to get Eq. (7). The similar approach can be applied to derive the life-stress model for the Lognormal distribution (ARL-Lognormal model). By setting $t_{median} = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_1 x_2$ and substituting it into the *pdf* of

Lognormal distribution, we will be able to get Eq. (8).

$$f(t,x_1,x_2)=\frac{\beta}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\left(\frac{t}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\right)^{\beta-1}\times exp\left[-\left(\frac{t}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\right)^{\beta}\right] \tag{7}$$

$$f(t,x_1,x_2)=\frac{1}{\sqrt{2\pi}\sigma t}\exp\left[-\frac{1}{2}\left(\frac{\ln t-\ln(b_0+b_1x_1+b_2x_2+b_3x_1x_2)}{\sigma}\right)^2\right] \tag{8}$$

Parameters estimation with MLE

Notations

n ：the sample number

t_i ：the exact failure time of the i^{th} sample

t_i' ：the running time of the i^{th} sample with suspension

x_{1i} ：the first stress of the i^{th} sample

x_{2i} ：the second stress of the i^{th} sample

F_e ：the number of exact times-to-failure data points

S ：the number of suspended data points

Life-stress model parameters of Weibull distribution

The log-likelihood function of Weibull distribution can be obtained as follows:

$$\begin{aligned}\Lambda&=\ln\prod_{i=1}^{n}f(t_i;\beta)\\&=\sum_{i=1}^{F_e}\ln\{\frac{\beta}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\left(\frac{t_i}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\right)^{\beta-1}\\&\quad\times\exp\left[-\left(\frac{t_i}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\right)^{\beta}\right]\}-\sum_{i=1}^{S}\left(\frac{t_i'}{b_0+b_1x_1+b_2x_2+b_3x_1x_2}\right)^{\beta}\end{aligned} \tag{9}$$

The estimates of model parameters will then be found by solving $\frac{\partial\Lambda}{\partial\beta}=0, and\ \frac{\partial\Lambda}{\partial b_i}=0,$ for i=0,1,2,3 where

$$\frac{\partial \Lambda}{\partial \beta}=\sum_{i=1}^{F_e}\ \frac{1}{\beta}+\ln\frac{t_i}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}$$
$$-\left(\frac{t_i}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)^{\beta}\ln\left(\frac{t_i}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right) \quad (10)$$
$$-\sum_{i=1}^{S}\ \left(\frac{t_i'}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)^{\beta}\ln\left(\frac{t_i}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)$$

$$\frac{\partial \Lambda}{\partial b_0}=\sum_{i=1}^{F_e}\beta\left(\frac{1}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)+\beta\left(\frac{t_i{}^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right) \quad (11)$$
$$-\beta\sum_{i=1}^{S}\ \left(\frac{t_i'^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)$$

$$\frac{\partial \Lambda}{\partial b_1}=\sum_{i=1}^{F_e}\beta\left(\frac{x_{1i}}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)+\beta\left(\frac{t_i{}^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)x_{1i} \quad (12)$$
$$-\beta\sum_{i=1}^{S}\ \left(\frac{t_i'^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)x_{1i}$$

$$\frac{\partial \Lambda}{\partial b_2}=\sum_{i=1}^{F_e}\beta\left(\frac{x_{2i}}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)+\beta\left(\frac{t_i{}^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)x_{2i} \quad (13)$$
$$-\beta\sum_{i=1}^{S}\ \left(\frac{t_i'^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)x_{2i}$$

$$\frac{\partial \Lambda}{\partial b_3}=\sum_{i=1}^{F_e}\beta\left(\frac{x_{1i}x_{2i}}{b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i}}\right)+\beta\left(\frac{t_i{}^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)x_{1i}x_{2i} \quad (14)$$
$$-\beta\sum_{i=1}^{S}\ \left(\frac{t_i'^{\beta}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})^{\beta+1}}\right)x_{1i}x_{2i}$$

Life-stress model parameters of Lognormal distribution

The log-likelihood function of Lognormal distribution can be obtained as follows:

$$\Lambda=\ln\prod_{i=1}^{n}f(t_i;\sigma)$$
$$=\sum_{i=1}^{F_e}\ln\{\frac{1}{\sigma t_i}\Phi\left[\left(\frac{\ln t_i-\ln(b_0+b_1x_1+b_2x_2+b_3x_1x_2)}{\sigma}\right)\right] \quad (15)$$
$$+\sum_{i=1}^{S}\ln\left[1-\Phi\left(\frac{\ln t_i^{'}-\ln(b_0+b_1x_1+b_2x_2+b_3x_1x_2)}{\sigma}\right)\right]$$

The estimates of model parameters will then be found by solving $\frac{\partial \Lambda}{\partial \sigma}=0, and\ \frac{\partial \Lambda}{\partial b_i}=0,$ for *i*=0,1,2,3 where

$$\frac{\partial \Lambda}{\partial \sigma}=\sum_{i=1}^{F_e}\left(\frac{\left[\ln(t_i)-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})\right]^2}{\sigma^3}-\frac{1}{\sigma}\right)+\frac{1}{\sigma}\sum_{i=1}^{S}\frac{\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)\Phi\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)}{1-\Phi\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)} \quad (16)$$

$$\frac{\partial \Lambda}{\partial b_0}=\sum_{i=1}^{F_e}\left(\frac{\ln(t_i)-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma^2}\right)\left(\frac{1}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right)+\sum_{i=1}^{S}\frac{1}{\sigma}\frac{\Phi\left(\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})\right)}{1-\Phi\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)}\left(\frac{1}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right) \quad (17)$$

$$\frac{\partial \Lambda}{\partial b_1}=\sum_{i=1}^{F_e}\left(\frac{\ln(t_i)-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma^2}\right)\left(\frac{x_{1i}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right)+\sum_{i=1}^{S}\frac{x_{1i}}{\sigma}\frac{\Phi\left(\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})\right)}{1-\Phi\left(\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)\right)}\left(\frac{1}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right) \quad (18)$$

$$\frac{\partial \Lambda}{\partial b_2}=\sum_{i=1}^{F_e}\left(\frac{\ln(t_i)-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma^2}\right)\left(\frac{x_{2i}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right)+\sum_{i=1}^{S}\frac{x_{2i}}{\sigma}\frac{\Phi\left(\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})\right)}{1-\Phi\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)}\left(\frac{1}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right) \quad (19)$$

$$\frac{\partial \Lambda}{\partial b_3}=\sum_{i=1}^{F_e}\left(\frac{\ln(t_i)-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma^2}\right)\left(\frac{x_{1i}x_{2i}}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right)+\sum_{i=1}^{S}\frac{x_{1i}x_{2i}}{\sigma}\frac{\Phi\left(\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})\right)}{1-\Phi\left(\frac{\ln(t_i')-\ln(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}{\sigma}\right)}\left(\frac{1}{(b_0+b_1x_{1i}+b_2x_{2i}+b_3x_{1i}x_{2i})}\right) \quad (20)$$

EXAMPLE

In this section, we use an example to demonstrate the method developed in section 2. The life time of an electronic part is assumed to be affected by both temperature and humidity. A 2^2 full factorial design is applied on the ALTs to test system reliability of this product. The temperature stress is set at either a high level of 398K or at a low level of 375K. The humidity stress is set at either a high level of 0.8% or at a low level of 0.4%. The design matrix with failure data is given as Table 1. The following steps are then applied on the ALT data.

Table 1: Failure data of given test stresses.

Temperature(K)	Humidity(%)	Failure time (hr)
375	0.4	7929
375	0.4	9863
375	0.4	12501
375	0.4	20956
375	0.8	2883
375	0.8	3483
375	0.8	4442
375	0.8	6164
398	0.4	6054
398	0.4	9093
398	0.4	12204
398	0.4	15646
398	0.8	1480
398	0.8	1548
398	0.8	1625
398	0.8	4152

Step1. Both temperature (τ_1) and humidity (τ_2) are transformed into coded variables (x_i) with (21)

$$x_i = -1 + 2\left(\frac{\tau_i - \tau_{i,L}}{\tau_{i,U} - \tau_{i,L}}\right) \quad \text{for } i = 1,2 \qquad (21)$$

where $\tau_{i,U}$ is the high-level value, and $\tau_{i,L}$ the low-level value of stress *i*.

After the transformation, the high-level and low-level stress values can be indicated by +1 and -1 respectively. We then substitute the coded variables into Eq. (11) to develop ARL-Weibull model. The model parameters (β, b_0, b_1, b_2, b_3) could be found by solving the partial derivative equations (10) through (14) by the Newton-Raphson method. The parameter estimates obtained are $\beta = 0.97$ 、 $b_0 = 75505.5$ 、 $b_1 = -22853.5$ 、 $b_2 = -5086.5$ 、 $b_3 = 5033.5$. The scale parameters (η) under different stress levels are obtained by setting $\eta = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_1 x_2$ and their values are shown in Table 2.

Table 2: Estimates of Weibull scale parameter (η).

Scale Parameter η (hr)	Temperature x_1 (coded)	Humidity x_2 (coded)
108479	-1	-1
88239	-1	1
52705	1	-1
52599	1	1

Step 2. The reliability software Weibull++ from ReliaSoft Co. is used to simulate the right-censored failure data. It is assumed that 20% of the test samples are suspended (without failure at the end of test time). The test sample group sizes of each specific test stresses ($\square_1,\square_2$) are set as 5, 10, and 40 respectively. By repeating the same parameter estimation procedure as in step 1, we will be able to obtain the results listed in Table 3. By substituting the model parameters (b_0, b_1,$\square_2$,$\square_3$) into Eq. (6), we will be able to get the life-stress model for the considered test stresses ($\square_1,\square_2$) under a given sample size.

Table 3: ARL-Weibull model parameters with 20% censored data for n=20,40,160.

Sample size, n	β	b_0	b_1	b_2	b_3
20 (2^2x5)	0.720	45106.18	-24794.00	-3161.31	-1416.70
40 (2^2x10)	0.858	54296.73	-11652.30	-5682.93	2128.39
160 (2^2x40)	0.832	55444.50	-21720.40	-8631.42	7614.46

CONCLUSIONS

In this study, we develop the RSM-based life-stress models for multiple-stresses ALT by assuming a linear relationship between the life (response) and the stresses (design factors). The lifetime distribution of test units is assumed to be either a Weibull distribution or a Lognormal distribution. The model parameters are estimated by the Maximum Likelihood Estimation (MLE) technique. From the example in last section, we demonstrate that the proposed approach is simple and straightforward to use in developing life-stress model with RSM first-order prediction equation. This method can be easily applied to other location-scale-based life distributions as well.

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DIFFERENT INTENSITY OF INTER-FIRM COLLABORATION IN OPEN BUSINESS MODEL: A STUDY OF TAIWANESE CONVENIENCE STORE INDUSTRY

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ABSTRACT

This paper draws on a comparative case study design to investigate how Taiwanese convenience store chains use different intensity of inter-firm collaboration to develop new services with their suppliers. Using empirical evidence from case studies of the development of two e-commerce services (i.e. the online shopping with pick-up at store service and the multiple media kiosk service) developed by convenience store chains in Taiwan, this study found that the degree of intensity in inter-firm collaboration is influenced by the degree of task complexity and the degree of project newness. When the task is complex and is associated with a focal firm's development activities, case companies often collaborate more intensely with suppliers. Case companies also adopt less intense inter-firm collaboration with some suppliers when the development task is simpler and can be separated from the focal firm's development activities. In addition, when case companies developed different business modules for the MMK service, they also collaborate with suppliers on the basis of different degrees of newness in the project. Case companies adopt more intense inter-firm collaboration with the first entrant to identify its IT requirements and problems and share the related knowledge to reduce the technological uncertainty of a new business module. Once the requirements and restrictions of the new business module have been clearly defined, the case companies adopt lower degree of inter-firm collaboration with the second entrant, in order to quickly expand the scope of the existing business module.

Keywords: Intensity of inter-firm collaboration, Open business model, Task complexity, Project newness

INTRODUCTION

Recently, Chesbrough (2003) has proposed the open business model, which, compared with traditional business models, can help a firm reduce the development cost and time of innovation by tapping into external sources of knowledge and leveraging external knowledge in different phrases of new product development. Open business model encourages a firm to source valuable knowledge/resources from external firms or share the internal, valuable knowledge/resources of external firms in order to create value. In open business model,

firms must first recognize and access the external knowledge/resources that they need, using different ways (e.g. licensing, ventures, and spin-offs) to share internal innovation so that other companies can share the added value. However, the relevant studies of open innovation mainly use different types of openness to investigate a focal firm's behavior with external companies in the process of value creation (Lichtenthaler, 2008; Lazzarotti and Manzini, 2009). There is less empirical evidence to investigate how a firm adopts different degrees of collaboration intensity with external firms in open business model which facilitates the acquisition of relevant knowledge/ resource for value creation.

This paper aims to investigate what degree of intensity of inter-firm collaboration is employed by Taiwanese convenience store chains to cooperate with their suppliers in the process of new service development. The main research questions include: 1) What degree of intensity of inter-firm collaboration should be adopted to coordinate new service development activities with external actors and in which circumstances? 2) Does the adoption of intensity of inter-firm collaboration vary with different service developments? The present research adopts the classification of intensity of cooperation based on Fliess and Becker's (2006) research and incorporates the classification of coordinated development from Petersen et al. (2005). The most important forms of inter-firm cooperation include contract development, coordinated development, and joint development are selected and can be ranged from lower degree of collaboration intensity to higher degree of collaboration intensity. The different degrees of intensity of inter-firm collaboration are defined by indicating the different responsibilities of the supplier in the specification design associated with the decision making process. The contribution that this study aims to make is to enhance understanding of the adoption of intensity of inter-firm collaboration in facilitating sourcing external knowledge during new service development process. The adoption of collaboration intensity helps to distinguish more clearly the different firms' responsibilities, degree of interaction between firms, and decision making process in open innovation approach.

Taiwanese convenience store chains often collaborate with external firms, group companies or competitors in order to acquire and integrate multiple sources of knowledge and resources for service innovation. They combine acquired related resources with the existing advantages of 24-hour service, high store density, strong information system, and professional distribution systems to carry out "Clicks and Mortar" services, which in turn, help them respond quickly to market dynamics and consumers' needs. This study draws on empirical evidence from the four dominant convenience store chains in Taiwan. Two e-commerce services (i.e. the online shopping with store pick-up service and the multiple media kiosk service) were selected to address the issue of intensity of inter-firm

collaboration during service innovation process. Different degrees of intensity of inter-firm collaboration are identified and compared across four case companies and two selected services in this study. Semi-structured interviews were adopted in the data collection process which allows for two-way communication and the flexibility to probe for details as well as gaining a range of insights on research issues. Interviews were conducted with managers who were involved in the development of the aforementioned services from case companies and their collaborating firms. The interview data were analyzed by cross-case synthesis to summarize the findings from the individual cases and identify the similarities and the differences between the two service development projects.

The rest of the paper is set out in the following way: In the next section, the literature regarding open business model and intensity of inter-firm collaboration are reviewed. The methodology of the research is then described, followed by a discussion of the findings. The conclusions and managerial implications are discussed in the final section.

THEORETICAL BACKGROUND

Open business model

Open innovation can be seen as encouraging and searching for innovation opportunities from a broad range of internal and external resources and then assimilating these within a firm's capabilities and sources for delivering these opportunities via internal or external channels (West and Gallagher, 2006). Within the closed business model, firms recruit talented, intelligent people and invest much in R&D activities, which themselves develop and produce new business, in order to secure the market first and outperform their competitors in their field. This implies that successful innovation relies on control from the focal firm. The firm tends to control everything and invests in R&D activities to develop new projects internally in order to prevent its competitors from profiting from its ideas. In terms of specific knowledge related to product/service development which is widely distributed over different types of actor, different companies must be involved in contributing to it. The open business model can reduce the costs of developing an innovation by using external knowledge to tap into a firm's innovation process and can reduce the time taken to enter another market by adopting external channels to catch additional revenue. More specifically, an open business model facilitates new product or service creation and brings additional value to a firm or group of firms by aiding collaboration with external companies, with a view to taking internal immature or complementary technology to the market (Chesbrough, 2006).

The concept of open innovation encourages a firm to acquire complementary resources from external firms and share its relevant resources in order to create value at different phrases of the innovation process. This means that, for value creation, resources, knowledge and individuals can inflow and outflow between different companies. However, some studies argue the potential problems of open business model and criticize its concept (Dahlander and Gann, 2007; Trott and Hartmann, 2009; Lazzarotti and Manzini, 2009). Some writers argue that adopting the open business model may lead to the leakage of commercially sensitive knowledge, because it encourages firms to share their valuable knowledge/resources with external companies for commercialization (Trott and Hartmann, 2009). Moreover, Lazzarotti and Manzini (2009) also propose that adopting an open business model may increase the cost, because of searching and testing several solutions with external firms in the innovation process. They also argue that if the number of participating firm increases, the coordination and control between firms may also increase based on the transaction cost view. It would be interesting to explore what kinds of cooperation mechanisms are appropriate in the process of open innovation. This is because the concept of open innovation does not specify in advance how to manage the collaboration between firms in order to reduce such potential risks as hold-up risk and spillover risk.

In addition, some studies argue that the concept of open innovation, while a new concept on theoretical grounds, can be found in practice in many firms and industries (Trott and Hartmann, 2009). The concept of open innovation can be found in previous studies on innovation management which emphasize cooperation with external actors in order to acquire and share complementary knowledge/resources and to reduce development risks, showing that the innovation process often involves different degrees of openness (von Hippel, 1988; Faulkner, 1995; Tidd and Bessant, 2009). Firms in different industries can be found to adopt different types of cooperation and alliance, such as licensing, outsourcing, joint venture, industrial cluster and innovation networks. Moreover, some studies argue that the concept cannot be separated into a simple dichotomy between open and closed approaches (Dahlander and Gann, 2007; Trott and Hartmann, 2009). These studies suggest that further research should pay more attention to exploring the different degrees and types of openness and the extent to which a firm can benefit from external and internal resource/knowledge in the innovation process. This view provides an opportunity to investigate the use of various collaboration strategies open to a company and the types and contexts of sources of innovation (Lazzarotti and Manzini, 2009). Recently, some studies have begun to identify different types of openness (Dahlander and Gann, 2007; Lichtenthaler, 2008). For example, Dahlander and Gann (2007) claim that there are three types of openness, taking into account: 1) appropriability – different degrees of formal and informal protection; 2) the number of sources of external innovation; and 3) formal and informal

relationships with external actors. Lichtenthaler (2008) also defines two dimensions, the extent of external technology acquisition and the extent of external technology exploitation, to investigate a company's behaviour in the innovation process. However, the above studies mainly focus on using different types of openness to investigate a focal firm's behavior with external companies in the process of value creation. There is less empirical evidence to investigate how a firm adopts different degrees of collaboration intensity with external firms which contributes the acquisition of relevant knowledge/ resource between firms in open business model.

Intensity of inter-firm collaboration

According to Fliess and Becker's research (2006), several possible types of cooperation design can be distinguished according to the different type and intensity of the contractual relationship. The intensity of cooperation between firms ranges from internal development, know-how exchange, which have a lower intensity of cooperation, to coordinated development, joint development and contractual joint ventures, which have a higher intensity of cooperation. The most important three forms of cooperation, including contract development, coordinated development and joint development, provide better insights into the black box of supplier integration in new product development. These different forms of inter-firm cooperation can be classified by the different levels of responsibility between customer and suppliers in developing a new product. Contract development is based on the contract with suppliers who provide separated components/services of new service/product developments to customers. It is difficult for the customer to influence the development process, because the customer is involved only in coordination meetings. The form of inter-firm collaboration is used when the customer does not have enough resources/knowledge to develop new services/products. Coordinated development is defined as the kind in which suppliers focus on the separate components/services of new service/product developments and some tasks are developed by the customer. There are three type of coordinated development: asymmetrical cooperation, black box cooperation and systems partnership (Gerpott, 1999; Tani and Wangenheim, 1998). Asymmetrical cooperation can be defined as the kind in which detailed instruction is provided by customer to supplier. Black-box cooperation means that a single module is developed by the supplier for the final product. System partnership means that the supplier develops a complex module of the final product and integrated pre-suppliers. This classification of coordinated development implies that customers and suppliers have different levels of responsibility in new product development. However, the present research argues that the above classification of coordinated development is somewhat ambiguous, because the specification of the decision-making process in a new service development has not been

taken into account. Petersen et al. (2005) suggest that different levels of supplier integration are: 1) White-box cooperation, 2) Grey-box cooperation and 3) Black-box cooperation. White-box cooperation means that the buying company makes all the design and specification decisions but informally discusses the specifications with the supplier. Grey-box cooperation means that the buyer and supplier share related information and technology and joint decision making about specifications. Finally, black-box cooperation means that the buyer informs the supplier of his requirements and then gives the latter almost total responsibility to develop the project requirements. The buyer only reviews the specifications of the purchased items. Compared with contract development and coordinated development, joint development is based on regular cooperation, in which teams are formed by the supplier's staff and the customer's staff. These teams can work in the same place or cooperate by using a high level of information exchange and regular coordinated meetings to integrate supplier and customer from different places. The form of development could be adopted in a new service/product development if the development project cannot be divided into different modules and assigned to customer or supplier. Building on the above discussion, the present research adopts the classification of intensity of cooperation based on Fliess and Becker's (2006) research and incorporates the classification of coordinated development from Petersen et al. (2005). Three forms of cooperation (i.e. including contract development, coordinated development, and joint development) are selected to investigate the intensity of inter-firm collaboration between convenience store chains and their suppliers in the process of developing new services. In addition, the present research provides clear distinctions in the coordinated development on the basis of different levels of responsibility for specification design between the firms which are associated with the decision making process. Table 1 defines the degree of different intensity of inter-firm collaboration by indicating the different responsibilities of the supplier in the specification design associated with the decision making process. This can be used to clarify the different degrees of intensity of cooperation between the convenience store chains and their suppliers in the two selected service developments.

Table 1: The definition of different degrees of intensity in inter-firm collaboration.

Low ***Intensity of inter-firm collaboration*** High	**Contract development**	Customer and supplier based, with a contract to define the objects, tasks and restrictions between them. Supplier performs development activities separately from the customer.	
	Coordinated development	***Asymmetrical cooperation***	Customers directly provide detailed specification or instruction to suppliers for developing the final product/service.
		White-box cooperation	Customers informally discuss with suppliers the specifications and then make their own decisions about specifications.
		Grey-box cooperation	Customers and suppliers share relevant information/knowledge and then make decisions together about the design specifications
		Black-box cooperation	Suppliers take almost all responsibility for developing modules for the final product. Customers make known their requirements only and review the design specifications.
		Systems partnership	Suppliers develop the complex part of the final product/service and integrate the pre-suppliers in the development process.
	Joint development	Customers and suppliers regularly form a project team involved in the development activities.	

Source: Classification integrated from Fliess and Becker (2006) and Petersen et al. (2005).

The following questions will be answered in this paper:

1. What degree of intensity of inter-firm collaboration should be adopted to coordinate new service development activities with external actors and in which circumstances?
2. Does the adoption of intensity of inter-firm collaboration vary with different service developments?

RESEARCH DESIGN AND METHOD

This paper focuses on the intensity of inter-firm collaboration between Taiwanese convenience store chains and their partners in new service development process. For this purpose, this research uses a comparative case study design which facilitates an empirical inquiry into investigating a contemporary phenomenon within its real-life context (Yin, 2003). This research draws on empirical evidence from the four convenience store chains in Taiwan. Two e-commerce services (i.e. the online shopping with store pick-up service and the multiple media kiosk service) in the convenience store industry were selected to address the research questions.

Study Population and Unit of analysis

The study population of this research includes the Taiwanese convenience store chains and their cooperative firms involved in the selected service development. The four convenience store chains (including Company E, Company F, Company H, and Company O) which together control 95.51% of the market in Taiwan have been chosen in order to fulfill all the required data collection tasks in my research case. The unit of analysis of this research is the new service development project. Online shopping with pick-up at store service and multiple media kiosk service were selected for investigating how convenience store chains use different intensity of inter-firm collaboration with their suppliers for new service development. Their suppliers include logistic companies (i.e. third party distribution company and distribution company owned by convenience store chain), IT system supplier, applied IT system supplier, service content companies, and hardware manufacturing companies, etc. were also chosen to fulfill required data in the present research.

Data collection and analysis

Two methods of data collection were used in this research: documentation and interviews. Secondary data were gathered from periodicals, books, magazines, newspapers, research reports published by research institutes, corporate websites, and annual reports published by case companies and their partners. Semi-structured interviews were also adopted in the data collection process as they allow for two-way communication and the flexibility to probe for details as well as gaining a range of insights on research issues. In total, there were 42 interviewees from the four convenience store chains and their suppliers participating in this study. Interviewees include managers and section staff of convenience store chains and the staff of suppliers who were involved in the selected service development projects. Some informants were interviewed twice. All together, 52 interviews were conducted. Before data analysis, interviews were fully transcribed. Relevant interview extracts were translated from Chinese to English by one of the authors, who is bilingual.

The interviews were analyzed using the thematic framework approach (Gibbs, 2008). In developing a thematic framework which represents the patterns and relationships in the interview data, I drew on the existing literature and research questions to create codes and to identify key thematic ideas. The thematic framework was then applied to guide initial data analysis in order to understand how Taiwanese convenience store chains use different degree of intensity of inter-firm collaboration to acquire external resources/ knowledge and share internal knowledge with suppliers in the process of new service development. Moreover, cross-case synthesis (Yin, 2003) was chosen as the analytical technique to

summarize the findings from the individual cases. This technique is also useful in identifying the similarities and the differences between the two service development projects. The findings of this present study are presented next.

RESEARCH FINDINGS

Intensity of inter-firm collaboration between case companies and their suppliers

This section investigates the intensity of inter-firm collaboration between convenience store chains and their suppliers in the process of two selected service.

Online shopping with pick-up at store service

The four convenience store chains in Taiwan split up two groups to develop this service. To do so, Company E initially formed a project team with its affiliated companies. Company E finally authorized its affiliated company to take the main role in developing this service and coordinating with the other affiliated companies owned by Company E. The other convenience store chains formed a joint venture to develop this service and cooperated with suppliers (e.g. a third party distribution company and an IT system supplier) in developing fundamental functions (e.g. logistics and IT functions).

Regarding to the intensity of inter-firm collaboration between convenience store chains and their suppliers, the four convenience store chains played different roles in developing the online shopping with pick-up at store service. In the first stage, Company E originally used joint development with its affiliated companies (a logistic company and an IT system supplier) and formed a project team Due to concerns over service capacity and the security of the goods, Company E finally authorized its group company – Company P – to continue to develop it in the second stage and provided marketing support after this service was temporarily closed. Company E played a key role in coordinating the cooperation between the group companies (Company P, the IT service provider and the logistic company) and in controlling the quality and progress of the service development in the second stage. Unlike Company E, the other convenience store chains (Companies F, H, O and N) used joint development to establish a new company – Company C – to develop this service for them. They also used Company C to buy some goods on their behalf in order to reduce purchasing costs (joint purchasing).

As regards the IT system supplier, Company E used coordinated development (systems partnership) with its group companies in the first stage and then in the second stage

involved the applied IT system suppliers by using contract development to develop some functional systems. This was because the IT system of the service was split into a main IT system (the convenience store's internal system, for example a POS system) and functional systems, since Company E had to ensure that the main IT system operated normally. Unlike Company E, the actors of the other group (i.e. the convenience store chains, third party distribution company, e-shops) who were involved in the first stage in this service development connected individually with the IT systems of the other actors. Next, the requirements and format of the information transfer were decided and integrated by Company F's IT department and its third party distribution company (grey-box cooperation) in the second stage. Finally, this group used coordinated development (systems partnership) with an external firm to develop the IT system for integrating the information flow between the different actors.

The development of the logistic function can be separated into two routines. The third party distribution companies provided storage, packing and delivery services for the e-shops and delivered consumers' orders to the distribution companies owned by the convenience store chains if the e-shops themselves could not deliver the goods to the distribution company of each chain. The distribution companies owned by convenience store chains delivered the consumers' orders to the various convenience stores. In the first stage Company E began by using joint development with its own logistics to deliver the goods to each store. When Company E authorized Company P to develop this service, it used coordinated development (systems partnership) with its own logistics in developing the logistical function. It also engaged in contract development with a third-party distribution company. The other group in the first stage used contract development with a third-party distribution company. The third-party distribution company delivered the goods direct to the stores of Companies F, H, O and N. Given the service capacity of the third-party distribution company, this group invited a new third-party distribution company in the second stage using contract development and delivering consumers' orders either direct to the distribution company owned by Company H or to the stores of Companies F and O. In the third stage, the third party distribution company no longer provided a delivery service from the e-shops to the distribution companies owned by Company H. This group invited another third party distribution company (by contract development) to provide a delivery service and to transport goods from the e-shops to the distribution company of each chain. However, the previous third party distribution company (in the second stage) still delivered goods to Company F, which finally acquired it, and it became a self-owned distribution company. Third party distribution companies cooperated with this group by using contract development. Both of them (Company E and Companies F, H and O) developed by contracts with e-shops. Table 2 summarises a cross-case comparison between different companies in the

development of the online shopping with pick-up at store service.

Table 2: Cross-case comparison of the different degrees of intensity in the inter-firm collaboration between two groups in developing the service of online shopping with pick-up at store.

	Company E	**Companies F, H and O**
Service developer	1. Company E formed a project team with affiliated companies in the first stage. 2. Company P was authorized to develop this service in the second stage (systems partnership).	1. Convenience store chains used joint development with Company C in decision- making in the first stage. 2. This new company (Company C) grew in prominence as it developed this service in the second stage.
IT system supplier	1. Joint development with an IT system supplier in the first stage. 2. Coordinated development with affiliated companies (systems partnership) in the second stage. 3. Involving applied IT system suppliers to develop different functional systems by using contract development.	1. The IT specification was initially developed by Company F and its cooperative distribution company (grey-box cooperation) in the second stage. 2. Coordinated development (systems partnership) with an external company to set up an integrated IT system in the third stage.
Logistics	1. Joint development with a self-owned distribution company in the first stage. 2. Coordinated development (systems partnership) with a self-owned distribution company in the second stage. 3. Contract development with third party distribution companies.	1. Coordinated development (systems partnership) with self-owned distribution companies. Companies F and O strengthened the intensity of the inter-firm collaboration from contract development to coordinated development (systems partnership) in different stages of the development. 2. Contract development with third party distribution companies.
E-shop	Contract development	Contract development

Source: Summarized by the author

Multiple Media Kiosk service

Four convenience store chains individually cooperated with different actors (the IT system supplier, hardware manufacturing company and service content company) in developing this service. Company E authorized its affiliated company (Company Q) to lead and coordinate different affiliated companies (IT system suppliers) in developing this service. Company Q also cooperated with a hardware manufacturing company and service content companies in order to acquire the essential resources (i.e. hardware and service content). Company F used a cross-functional team within its company and cooperated with different actors (i.e. a IT system supplier, hardware manufacturing company and service content company) in developing this service. Company H also used a cross-functional team within its company and cooperated with a hardware manufacturing company and service content company for this service development. In contrast, Company O played only a channel role in this development. The IT system suppliers and a hardware manufacturing company formed a team and cooperated with Company O to develop this service. The following section identifies the responsibility of each actor and the different degrees of intensity in the inter-firm collaboration adopted by four convenience store chains to develop the multiple media kiosk service.

Regarding to the intensity of inter-firm collaboration between convenience store chains and their suppliers, Company E used coordinated development (systems partnership) with its group company – Company Q – to develop and manage this service development. Company E played a key role in coordinating the different affiliated companies, providing marketing support and controlling the service quality in the development of this service. Companies F and H used cross-functional teams within their companies to develop this service. Company O provided only some space in a convenience store where the hardware could stand and payment could be collected. To consider the development of the IT system, Company E cooperated with its group companies (in a systems partnership) which took responsibility for different domains of the IT system. Company F basically used coordinated development (black-box cooperation) with the existing IT system supplier and provided what the existing IT system supplier required (e.g. the service requirements and a checklist). The existing IT system supplier also informally provided the relevant knowledge and suggestions to Company F in developing its IT system. Company H developed the IT system within its company. Company O used coordinated development (grey-box cooperation) with its suppliers to develop the IT system.

As regards hardware manufacturing, Company Q signed a manufacturing contract with a

hardware design and manufacturing company and became involved in the specification and design of its own hardware. This can be seen as an example of coordinated development (grey-box cooperation). Company F also used coordinated development (grey-box cooperation) with its hardware supplier, which came up with a feasible specification and developed a prototype for Company F. Company H used coordinated development (asymmetrical cooperation) with a hardware manufacturing company and presented its requirements to this company.

To consider the cooperation between the service content providers and Companies E, F and H, the companies developed and signed a selling contract with some of the service content providers on the basis of their existing IT system or business module. The service contract provided suppliers with the specifications for developing a user-interface in the kiosk and connecting the IT systems, the operation procedure and the financial regulations. This is an example of contract development. The companies also used coordinated development (grey-box cooperation) with some service content providers when they mutually adjusted the IT requirements with their IT system supplier or developed a new business module in the kiosk. Table 3 shows different intensity of inter-firm collaboration between four convenience stores and their related partners in the development of multiple media kiosk (MMK) service.

Table 3: Cross-case comparison in intensity of inter-firm collaboration between four convenience stores in the development of MMK service.

	Company E	**Company F**	**Company H**	**Company O**
Service developer	Coordinated development (systems partnership)	Internal development	Internal development	Coordinated development (grey-box cooperation)
IT system supplier	Coordinated development (systems partnership)	Coordinated development (black-box cooperation)	Internal development	Coordinated development (grey-box cooperation)
Hardware manufacturing	Coordinated development (grey-box cooperation)	Coordinated development (grey-box cooperation)	Coordinated development (asymmetrical cooperation)	Coordinated development (grey-box cooperation)
Service content company	Contract development or Coordinated development	Contract development or Coordinated development	Contract development or Coordinated development	None

	(grey-box cooperation)	(grey-box cooperation)	(grey-box cooperation)	

Source: Summarized by the authors.

Cross-case comparison between two selected service developments in the issue of intensity of inter-firm collaboration

From the above discussion regarding the intensity of inter-firm collaboration in the development of two selected services, it appears that the companies under review tended to use a high degree of intensity in their inter-firm collaboration (coordination development-systems partnership) with suppliers in developing fundamental functions (e.g. IT function and logistics) when they developed the two selected services. This is because the task of these functions of integrating different actors or pre-suppliers to contribute to the development of new services is very complicated. In terms of the task, which is complicated because of the relationship between the companies under review and these suppliers (e.g. of the IT system and the logistics), the companies cooperate with suppliers intensively for the sake of identify possible problems and solutions, share related information/knowledge and control the progress and quality of the service when they developed these fundamental functions. For example, Company E, in particular, often used coordinated development (system partnership) with its group companies when it contributed to developing a new service framework. Companies F, H and O also used a high degree of intensity in their collaboration to prepare major IT system designs with external companies. The case companies also adopted a lower degree of intensity (e.g. contract development) in their inter-firm collaboration with some suppliers, such as e-shops and some of the service content companies. This is because the task of these suppliers can have been simply to define their object, provision and restrictions and separate them from the case companies' development activities. In addition, the case companies do not have enough resources/knowledge available to perform these tasks. Case companies used only coordination meetings with their suppliers to define the task to be done and the regulations to follow; they formed a contract with them in order to expand the scope of their services to the consumers. According to the above discussion, this present study can claim empirical evidence that the intensity of inter-firm collaboration with suppliers in the process of developing new services (in particular online shopping with pick-up at store service development) depends on the degree of task complexity in different functional developments. The degree of task complexity is often determined by the number of different actors or functions which must mesh together in the functional development of a new service/product. Both the service developments considered here belonged to e-commerce services and involved different functions for information transfer between

different actors. The development of the online shopping with pick-up at store service is the more complex of the two in the matter of integrating information transfer among the IT systems of different functional actors, e.g. distribution companies (logistic function), convenience store chains (marketing) and channel role and e-shops (product provider) and coordinating the existing operation procedures of the different functional actors to advance this service development. For example, the case companies have a higher intensity of inter-firm collaboration with the IT system suppliers because the latter often coordinate an IT system of related actors, such as a self-owned distribution company, third party distribution company, convenience store chain and e-shop, on the basis of different requirements and the restrictions of the actors' IT system in the development of the online shopping with pick-up at store service. According to previous studies, the relationship between intensity and task complexity in inter-firm collaboration has been initially identified: the intensity of inter-firm collaboration is high when a task is more complex (Nylen, 2007). Her research used different terms to define this intensity, including coordination, co-operation and integration, which focused on the degree of involvement and interaction among parties. This present study further used different forms of inter-firm collaboration to identify the intensity between cooperative firms. Different forms of inter-firm collaboration can help to distinguish more clearly the different firms' responsibilities and decision making in inter-firm collaboration.

Moreover, this present study further found that the degree of newness may also influence the adoption of intense inter-firm collaboration when the case companies cooperate with the service content companies in the development of the MMK service. This is because the convenience store chains provided an IT platform (kiosk) and identified different business modules to cooperate with the various service content companies in order to expand the scope of the MMK service. Some service content companies may provide similar service content in each business module. This service development mainly focused on the IT connection between the convenience store chains and the service content companies and promoted a new business module in the kiosk. According to the different degrees of newness in different business modules, the case companies used a higher intensity of inter-firm collaboration (grey-box cooperation) with some of the service content companies when they mutually adjusted the two IT systems for connection or developed a new business module in the kiosk. Case companies often cooperate more closely with suppliers to identify their IT requirements and potential problems and share the related knowledge/resource in order to construct a new business module. In addition, case companies developed a service contract and signed it with some of service content companies on the basis of the existing IT systems of case companies or developed a business module for the kiosk. The contract terms include the IT requirements, restrictions and

financial regulation to be followed and the operation procedure to be coordinated. According to previous studies, in developing new products the degree of project newness traditionally defines how much of the existing product must be changed or adjusted (Clark and Fujimoto, 1991; Griffin, 1997). The different degrees of project newness often involved different degrees of technological uncertainty in the process of developing new products. In order to reduce the technological uncertainty of a new product, previous studies suggested that focal firms can seek a closer relationship with the supplier and pool their technological information in developing a new product (Auster, 1992; Hagedoorn and Narula, 1996). This present study provides insight in identifying the relationship between supplier integration and project newness when focal firms develop non-fundamental functions and quickly expand the scope of the existing business module. Focal firms can adopt a lower degree of intensity of inter-firm collaboration with the supplier when the degree of project newness is relatively low (e.g. based on the existing operation of the focal firm). Additionally, the focal firm may use more intense inter-firm collaboration with the first entrant to identify potential problems and reduce its technological uncertainty to contribute to a new business module. A lower degree of inter-firm collaboration appears between the focal firm and the second entrant because of the lower technological uncertainty of the existing business module.

CONCLUSIONS AND MANAGERIAL IMPLICATIONS

The main focus of this study was to identify how the intensity of inter-firm collaboration varies across four cases and two selected service developments. This present study found that the degree of intensity of inter-firm collaboration is influenced by the different degrees of task complexity and of project newness in different service developments. Because the characteristics of the task are complex and associated with the focal firm's development activities in the functional development of developing new services, case companies often use very intense inter-firm collaboration with suppliers in order to integrate different actors' requirements, reduce technological uncertainty and further improve service quality. When a task is simpler and can be separated from the focal firm's development activities, case companies may use a lower degree of inter-firm collaboration with suppliers. Additionally, the degree of project newness may influence the intensity of the inter-firm collaboration in terms of different degrees of technological uncertainty. Focal firms adopt more intense inter-firm collaboration with the first entrant to identify its IT requirements and problems and share the related knowledge to reduce the technological uncertainty of a new business module. Once the requirements and restrictions of the new business module have been clearly defined, the focal firm adopts a lower degree of inter-firm collaboration with the second entrant, in order to quickly expand the scope of the existing business module.

This research offers some managerial insights. First, firms can cooperate more intensively with fundamental suppliers (e.g. IT system supplier and logistics) to lay the foundation of a new service. This close collaboration allows a focal firm to identify functional requirements and integration problem with its suppliers to contribute fundamental functions of a new service. Second, it may be more appropriate for firms to cooperate less intensively with non-fundamental suppliers when a project is not relatively new, as these suppliers have fewer essential resources and some market alternatives to contribute to the new service development. Focal firm can modulize the development activities of non-fundamental suppliers and keep many alternatives, to improve external sourcing. A lower level of interaction between firms may reduce the time and cost to administer arrangements with these suppliers.

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ELEMENTS AND IMPLEMENTATION OF PRODUCT DATA OWNERSHIP NETWORK

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ABSTRACT

The increasing amount of product data is creating more and more challenges for companies, not the least whit data management and data quality practices. Defining and assigning product data ownerships and its related functions, practices and processes, enterprises can enhance their product data quality. The purpose of this study is to introduce and review the concept of product data ownership network (PDON). Furthermore the current roles, practices and processes that PDON includes were defined from enterprise practice. The results point out enterprise-wide definitions, policies and guidelines, product data management activities, product data owners, roles and responsibilities, and enterprise's business functions to be the key elements and enablers of PDON. PDON is built around product data owners, who in the end have the responsibility over the product data. Besides product data owners, the supporting network needs to be built around them in order to enable their tasks towards product data. This network consists of other roles, different practices, and various functions. Implementation of PDON and Product data Maintenance related functions requires resources, investments and approval from the upper level management. Both empirical and theoretical researches revealed that poor data quality affects both the operational and the strategic sides of business. Therefore PDON takes a strategic importance which needs to be validated by the participation of the management.

Key words: Product data, data ownership, ownership network

INTRODUCTION

Modern companies are dependent on information systems and most business processes are supported by information systems (Lagerström and Johnson, 2008). Functionality of these systems is dependent heavily on data concerning products. Efficient product data management practices have become one of the key aspects for business efficiency. At the same time enterprises are lacking the understanding how to manage data integrity and availability in daily operations (Reid et al., 2007). At the same time collaboration network has extended to cover partners, suppliers and contractors. As a result of the IT systems, collaboration network extension, the amount of data created and handled over products' lifecycles has become very extensive, which has led to realization of the importance of effective data management. (Stark, 2005; Saaksvuori and Immonen, 2008)

In companies a large number of stakeholders are involved during product lifecycle (PLC). As the number of individuals and organizations grows larger, it brings many kinds of challenges, not least with the product data. Companies, which are not able to control their product data, will face major challenges on getting their products under control (Stark, 2005). Typically companies do not know what product data they have, how critical it is, the sources that exist for critical product data, or the degree of redundancy of their product data assets (Khatri and Brown, 2010).

One way to handle the growing amount of product related data are PLM and PDM systems (product life cycle/data management). These systems help to organize, store, maintain and utilize product related data. Furthermore, PDM helps enterprises to manage their operations electronically (Stark, 2005). Because PDM systems do not clearly represent the linkage of product management through lifecycle, the wider managerial view, product lifecycle management (PLM), has been arisen. But even with PLM, the focus of data management is strongly focusing on engineering data management only in product design and manufacturing operations, letting the key point of the concept, lifecycle, rather untouched (Kropsu-Vehkapera et al., 2010).

Enterprise architecture (EA) model can be seen as a tool to define and develop enterprise's data related functions further. Although EA model is used to develop the whole enterprise, this research focuses on the information architecture discipline. The scope of information architecture is to define the enterprise's essential product data, assign the ownerships of product data and to describe the exchange of product data between different stakeholders. The results occurring from the work of information architecture work can be used as basis when defining and building PDON – product data ownership network.

Enterprises have also other systems (e.g. ERP, sales configurators) and applications (e.g. CAD-tools, CRM-tools) that use product related data (Loshin, 2001) creating even more challenges on managing product data effectively. Therefore, a set of enterprise-wide guidelines, policies and functions are needed to ensure functional product data management and quality of product data. Product data responsibilities are usually allocated according to organizational

units and related business process responsibilities. It is common that the person who creates the data is also the owners of the data or in some cases there might be an organization carrying the responsibility over data ownership. (Kropsu-Vehkapera et al., 2010.) Undefined data ownerships are fatal for business processes. Gaps and flaws in product data ownerships may complicate the whole order-delivery process and cause major business losses. The responsibility of product data cannot be left just for data owners, there has to be defined and implemented guidelines and policies for them to follow as well as a supporting network. This network's responsibility is to help and support data owners to outperform their tasks (Stark, 2005; Saaksvuori and Immonen, 2008).

Towards former background, this research aims to introduce and review the concept of product data ownership network (PDON). The concept of PDON is studied from the product data management, data governance and data quality point of view. The increasing amount of product data is creating more and more challenges for enterprises, not the least whit data management and data quality practices. Defining and assigning product data ownerships and its related functions, practices and processes, enterprises can enhance their product data quality. Product data ownership network also enables better and more efficient product data management practices. Research problem is divided on the following three research questions:

RQ1: What are the elements of PDON?
RQ2: What kind of roles, practices and processes should PDON include?
RQ3: What are the requirements for enterprise to create and implement PDON?

RESEARCH PROCESS

Figure 1 illustrates the research process applied in this study. First, a literature review strives for defining the key elements of PDON. Second, company representatives and specialists were interviewed on defining roles and responsibilities, working practices, processes and functions that are currently thought to be the key PDON practices in modern enterprises. In addition, the interviews were conducted to clarify what are the requirements of PDON implementation for an organization and enterprise. This study compiles all the essential parts and elements of a PDON and presents generic guidelines for building it.

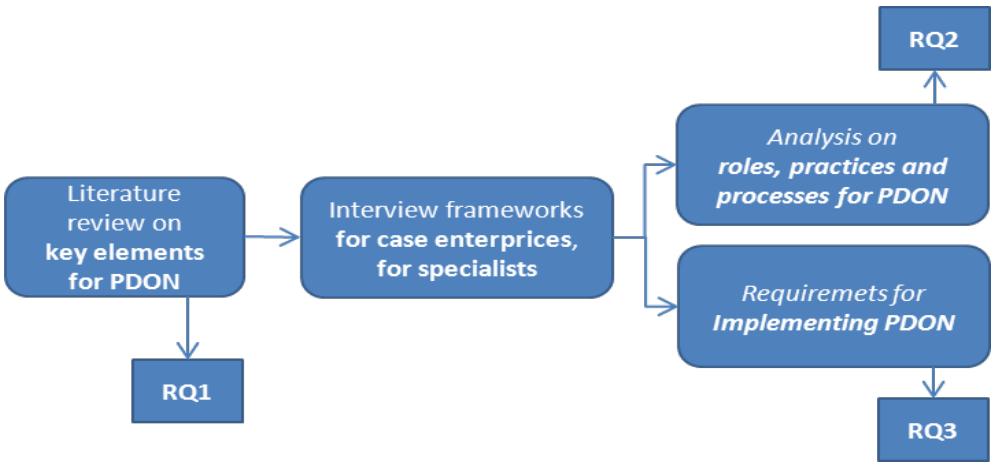

Figure 1: Research process.

The empirical data was collected by interviewing responsible data managers of companies and specialists with extensive experience consulting companies on product data management. In addition, the empirical material included documentation handed over by interviewees. The goal of interviews was to find out the current PDON definitions and functions in nowadays business processes from two different viewpoints. The study consisted of total 13 interviews. Although the number of interviews is not statistically sufficient for qualitative analysis, it is irrelevant according to Alasuutari (2004). It's rarely possible to achieve sufficient number of interviews in order to be statistically important when doing qualitative analysis and research. The amount of interviews made were left short from intended due to the fact that PDON was lacking in many enterprises, the maturity level of product data management was very low or the selected interviewee felt that one didn't have enough competence in order to answer the questions.

Interviews were done face to face at interviewee's place of employment or by phone. The scope of the interviews was to gather information about current definitions and functions of PDON. Interviewees were divided into separate groups; to the interviewees from case enterprises and to specialists. Thus, two distinct question frameworks were built for these groups (see Appendix 1). Question frameworks were based on the synthesis of the theoretical section and then modified to be suitable for both of the groups to be interviewed. The question frameworks were still slightly modified during the interviews in order to maximize the coverage of gathered research data and in order to leave room every interviewee to explain the subject freely. The questionnaire directed enterprises focused more on the actual working with PDON as the questionnaire for the specialists focused more on the requirements, challenges and benefits of PDON.

All the individual interviews were analysed separately in order to find the current roles, practices and processes that PDON includeswere defined. Also the challenges, benefits, and PDON implementation requirements were summarised. As a conclusion, the requirements that PDON creation and implementation sets for an enterprise was presented.

ELEMENTS OF PDON

Product data and ownership

In context of product lifecycle management product data is widely understood to covering all the information related to the product (Saaksvuori and Immonen, 2008). Product data can be divided for product master data and product related data. Master data describes the business-oriented properties of data objects that is used in diverse applications across the organization in multiple business processes (Loshin, 2001) and should be managed over company in an integrated fashion. There should be only one truth of data available when speaking on master data (Berson and Duboc, 2007). Product master data contains static data like product description, item code, weight, price, and suppliers (e.g. Nagi, 2001) as well as include configuration options and operation instructions (Yang et al., 2007).

From product data maintenance view,Van Alstyne et al. (1995) define data ownership as the right to determine usage rights to others. By usage rights they refer to ability to access, create, standardize and modify data. Duerr et al. (2004) state that data ownership should be connected to data preservation in order to ensure the future accessibility of the data. Berson and Dubov (2007) see data owners as individuals or stakeholders within the organization that has status to obtain and create data and have major role in distribution, access and controlling the content of the data.

Product Life cycle

Product related business functions trough out the product lifecycle (PLC), that create and/or use product data, can be divided into four major categories; product development, production, sales and marketing, and maintenance (after sales). It is important to understand that all these business functions need to be included and involved in PDON because they all have needs, requests and effects towards product data during the product lifecycle. All these functions also create product data, which needs to have assigned ownerships and made available for other business functions for their usage. (Stark, 2005; Sudarsan et al., 2005; Svensson and Malmqvist, 2002).

Because there are several actors (roles) from different business units working in PDON, it is important that they all have the same understanding of how the product data is created, distributed and maintained throughout the product lifecycle. Equally important is to have one single version of truth of product and its related data between business functions and between different actors. Policies and guidelines defined in PDON should be seen as enterprise-wide manner and those should standardize product data creation, distribution and maintenance related activities and processes between business units. Through standardization of procedures, business units can work more efficiently in co-operation with other business units and the consensus of product data related activities, processes and functions rises. (Levitt, 1965; Saaksvuori and Immonen, 2008)

In the early stages of product lifecycle, there is obviously product development function involved. Product development includes concept creation, product definition and designing of the new product. It is important to notice that in the early phases of PLC, the sales and marketing function is also active. This is not highlighted commonly in literature. During the product development, sales and marketing is creating sales brochures and developing promotion and launch materials. Even though it seems that sales and marketing has functions in all the phases during the time line of PLC, there can be found hardly any literature to support this. This makes it hard to place sales and marketing to the time line of PLC. After the product and its sales and promotion material has been created, the production and sales of the product can begin. Maintenance and services related to the product begins usually also at this point. Sales and marketing promotes the product during the production phase. After the product has reached its peak sales, the enterprise starts to decline the production and finally kills the product. Even though the production is concluded, the maintenance of the product can still remain for several years, in some cases even decades. Sales and marketing usually ends the promotion of the product not later that when the production ends, but it still may have some functions related to the product also during its maintenance phase. Depending on the product, at some point the maintenance function is also concluded and the lifecycle of the product comes to an end. (Andreasen et al., 1996; Svensson and Malmqvist, 2002; Shu and Wang, 2004, Saaksvuori and Immonen, 2008)

Product data ownership layers

There are several actors working with product data. All these actors have their own functions, effects and requirements towards product data ownership. The ownership can be categorized in different layers based on their hierarchy level (Figure 2).

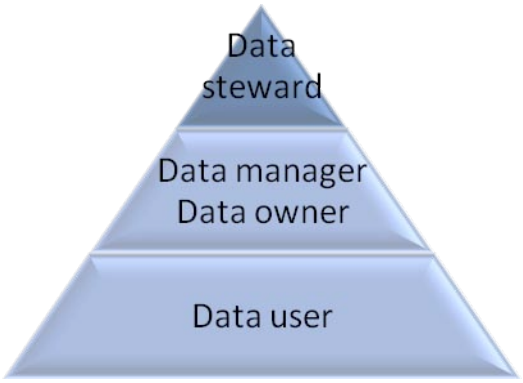

Figure 2: Product data ownership layers.

On the top of data ownership layers are data stewards. Their task is to define and help implementing product data ownership policies, requirements and functions according to the guidelines set up by enterprise and to improve the data flow throughout the enterprise.

The implementation of policies, requirements and functions is the responsibility of data managers, who are categorized in the next layer. It can be said that data managers are also

responsible of capturing, storing, retaining and disposing the product data, in other words, they are responsible of everything that concerns delivering and handling information. Data owners are typically also the creators of the certain product data they own. Their responsibility is to provide consistent product data that meets the quality standards and are always available for its users. Shortly said that data owners create and provide consistent product data, by using IT systems which provide the needed infrastructure for information delivery purposes. (Loshin, 2001; Becker, 2006; Berson and Dubov, 2007)

The lowest hierarchy level is data user. Data users must comply with the information management policies when they select the best information source to meet their needs. They must have applied authorities to the product data their using. Nevertheless data users mostly utilize product data in their tasks, they still must provide assistance to other stakeholders in order to improve product data ownership functions. Table 1 presents data ownership layers and responsibilities in RACI-chart. (Wende, 2007; Weber et al., 2009)

Table 1: Data ownership layers and responsibilities (Wende, 2007; Weber et al., 2009).

Task\Layer	Data Steward	Data Owner	Data Manager	Data User
Defining PDON policies, requirements and functions	R	I	C	I
Implementation of PDON policies, requirements and functions	R	I	A	I
Delivering and handling product data	C	A	R	I
Creation of data	C	A	I	C
Data quality ensuring	C	A	R	I

R - Responsible, A - Accountable, C - Consulted, I - Informed

Compiling key elements of PDON

Data governance is an essential part of PDON. It can be seen as a kind of enabling and supporting process operating behind the actual PDON function. Data governance is used to organize and implement roles, guidelines, policies, procedures, and standards for building up and maintaining PDON. (Cohen, 2006; Winter et al., 2001)

Like earlier presented, there are four major *business functions* that use PLC. There has to be information sharing and distributing between these functions in order to have the single version of truth concerning the product and data related to it. Under these disciplines are many roles and responsibilities that need to be fulfilled according to definitions made in data governance. Firstly, new product data needs to have owner. *Product data owners* (PDOs) primary responsibilities are to ensure the data quality, maintain the data and make it available

for other users needing it. Product data is created in every business function of an enterprise and therefore product data owners have to be found from all of these disciplines. (Andreasen et al., 1996; Svensson and Malmqvist, 2002; Shu and Wang, 2004, Saaksvuori and Immonen, 2008)

Besides product data owners, different business functions also include other *roles and responsibilities* concerning PDON. These commonly include e.g. making product data available for other disciplines, storing the product data or implementing and monitoring policies and guidelines defined by data governance. PDOs cannot operate product data by themselves; they need assistance from other roles in order to fulfill the demand set for the product data by the enterprise. To have a fully working co-operation a virtual network is needed and this can be called to fully operational PDON. Although literature defines the four business functions, it presents hardly any specific information about the roles and responsibilities under them or how are these related to each other concerning PDON. Therefore those cannot be unambiguously defined based on literature.

Information flow between business functions, from data owner (or creator) to data base and further to data user, must be organized and monitored. *Product data management* with policies and guidelines defined by data governance forms the foundation for data storage and distribution. Effective data distribution is vital for enterprises' business processes. Information gaps and delays can be costly. PDOs can ensure that the product data is in right form, at right time, at right place through product data management processes and protocols. Product data management integrates enterprise's disciplines and their data flows to an effective network. (Saaksvuori and Immonen, 2008; Loshin, 2001)

When constructed and maintained right, PDON can be huge benefit for an enterprise. But this doesn't happen by itself, it requires precise planning of functions and processes, following guidelines and policies as well as dedicated workforce to operate with it. Constructing PDON is heavily enterprise-specific manner and cannot therefore be unambiguously defined to fit in every enterprise or business area through literature. But still, the key elements that form the basis of PDON and data flows inside PDON can be presented (Table 2).

Table 2: Key elements of PDON.

Key element of PDON	Focus
Data governance	• Data governance is used to define, organize and implement guidelines, policies, procedures, standards, roles and responsibilities for building and maintaining PDON.
Product data management	• Is based on policies and guidelines defined in data governance. • Forms the foundation for data maintenance, distribution and storage. • Ensures that product data is in right form, at right place, at right time. • Integrates business functions and their product data flows to a single network.
Product data owner (PDO)	• Primary responsibility is to ensure data quality, maintain product data and make it available for other users. • PDOs have to be found from every business unit that creates product data and every part of product data needs to be owned.
Roles and responsibilities	• There has to be also other roles and responsibilities than PDOs involved in PDON. • These are to support and enable PDOs' activities in order to have functional PDON. • These roles and responsibilities cannot be unambiguously defined based on literature.
Business functions	• All the business functions are needed and have to be involved in PDON. • Product data is created and/or used in every business functions and therefore it has affects towards them. • There has to be single version of truth of the product and its related data. • Product data has to be made available for those needing it throughout the enterprise. Therefore product data sharing and distribution have to be established according to product data management guidelines and policies and it has to be implemented as an enterprise-wide manner.

Product data management and quality issues aren't solved by themselves. PDON can be used to ensure product data quality and distribution as well as making product data available for those needing it. Functional PDON requires hard work, dedication, comprehension, and most of all planning and defining. Enterprises must create visions and concepts and define that what is the data they want to manage and what are the processes, functions and systems to support the product data. These concept visions should support and be tied to the enterprises strategy and made as enterprise-wide manner.

KEY SUCCESS CRITERIA'S BASED ON THE INTERVIEWS AND LITERATURE

The scope of the interviews was to gather information about current definitions and functions of PDON. The amount of interviews made for case enterprises and specialists were left short from intended due to the fact that PDON was lacking in many enterprises, the maturity level of product data management was very low or the selected interviewee felt that one didn't have enough competence in order to answer the questions. Totally of 13 interviews were made for the case enterprises and specialists. Although the number of interviews is not statistically sufficient for qualitative analysis, it is irrelevant according to Alasuutari (2004). He states that it's rarely possible to achieve sufficient number of interviews in order to be statistically

important when doing qualitative analysis and research. The goal of interviews was to find out the current PDON definitions and functions in nowadays business processes from two different point of views. Summary of the results is in the table 3. Interviewees were divided into separate groups; to the interviewees from case enterprises and to specialists. Two distinct question frameworks were built for these groups. Question frameworks were based on the synthesis of the theoretical section and then modified to be suitable for both of the groups to be interviewed. Both of these frameworks were still slightly modified during the interviews in order to maximize the coverage of gathered research data.

Table 3. Collection of the essential answers from PDON point of view.

Role	Data ownership model	Key Elements of PDON	Data in scope
Enterprises	1. PLM directs the ownership 2. Corporate data ownership according to the enterprise structure 3. Ensure top management buy in.	1. Enterprise size 2. Organisation structures 3. Product Structure 4. Architecture and other guidelines	1. Guidelines and policies of the company define the data to be owned by PDON
Specialists	1. Implementing data ownership is difficult 2. Managing changes to ownership is difficult 3. Centralized data ownership and maintenance makes it easier	1. Product structure 2. Company structure 3. Existing roles and responsibilities 4. Guidelines and working instructions	1. Critical data (master data). 2. Other data to be considered case by case.

Roles, responsibilities and process

When creating and defining the concept of PDON, one of the challenges is to define the essential roles that it includes. Table 4 syntheses the finding from interviews and combines those according to literature review. Role-based approach to PDON is important for its functionality. These roles and their functions have to be defined enterprise-specific due to the differences between enterprises and business areas (table 3). What is common to all of these roles is that they must support the functions operated by data owners and create the supporting network around them.

Table 4: General roles and responsibilities that PDON should include and cover.

Examples of definition areas	Examples of content
Roles	What are the needed roles that PDON requires? • Data owner • Data administrator • Change manager
Responsibilities	What are the responsibilities of the roles? • Who distributes the product data? • Who is responsible of change management? • Who ensures data quality? • Who owns the product data?
Functions	What functions and activities are needed in PDON? • How is the data distributed and stored? • How is traceability organized? • How is data quality monitored? • What systems do we need? • How is support organized?
Data principles	What is the data we manage? • What are the uses of product data for the business? • How is the data defined and modeled? • How is the product structure constructed?

Starting point for role definition should be that roles represent the functions of the enterprise. This is to ensure that all data users and their view to the product data are covered. Some of these roles may include overlapping tasks due to the generalization.

Before defining any roles, it is important to highlight that PDON roles are not supposed to be main tasks for employees. Nobody should work only e.g. as product data owner. These roles has to be operated along with employees other duties due to the fact that PDON is supposed to be empowering background process for product data and quality management processes. It is also important to emphasize that individuals or organizations might have one or more roles assigned concerning PDON or there can be several actors operating under same role. This is depended on competence level that different actors have and should be decided as each case individually. It should also be pointed out that individuals or organizations operating these roles may also change during the different lifecycle phases of the product but the roles must move alongside with it throughout the lifecycle and be always assigned. Table 5 shows examples of responsibilities and potential roles.

Table 5: Example who should have responsibility to define the data owner roles.

Responsibility	Examples of potential roles
Definition of roles and responsiblities of PDON	• Enterprise data committee / council • Data steward
Implementation and monitoring of policies and guidelines	• Enterprise data committee / council • Data steward •Product data manager
Data delivery actions	• Product data manager • Data delivery specialist • Data owner
Overall responsibility of product, product data and product structure	• Product manager • Product data architecture • Product technical owner • Enterprise data modeler
Data quality	• Data owner • Data administrator • Data quality team • Data quality manager
Product change management	• Data owner • Change manager • Product change team
Support	• All the roles

There should also be a role, e.g. *product manager*, which has the overall responsibility of the product and product data over the lifecycle of the product. Product manager's responsibility is to ensure that all the needed information, product data, roles and functions concerning product are done or fulfilled before the product data can be released to the IT systems. One of the key responsibilities is to ensure that the product content meets the defined data model requirements which are based to EA. This means that essential product structure levels with right content is been ensured to guarantee smooth product launch and use in enterprise business processes. This type of structure levels are for example: sales structure, configuring structure, engineering structure etc. Also, the entire product related information, which is not included in enterprise's definition of product master data, has to be handled and ensured by this role.

Product data in the IT systems should also be maintained and its validity be ensured. This is administrative role, e.g. *data administrator* role. The data administrator role can be assigned for the one also having the ownership of certain part of product data, if not already included to the data owner's role. If enterprise chooses to have centralized ownership of product data, this role should be assigned to separate quarter, e.g. *data quality team*, which is responsible for all the product data quality related manners. This role may also include delivering the product data to the target systems and giving usage rights concerning product data.

During the product lifecycle, there are usually many changes made to the product and its related data. These changes must be handled with care in order to keep the data and product structure correct in IT systems. Enterprises can set up a specific role, *change manager*, to handle product changes or it can be included in data owner's role. When a product change is requested, the responsible for that part of the product needs to be informed and change management process started. The responsible one needs to analyze the change, implement and verify it, and follow-up that the change is done to the product and especially to the product data and structure.

Empirical research revealed also that PDON needs a supporting role and network to ease up and enhance the tasks of different PDON roles and players. Supporting role should be included in all the other roles in PDON but there should also be dedicated players that can be asked for assistance in the end. If someone has difficulties to do one's tasks, there should always be a way to get help fast and easily. For example data owner in R&D might be responsible of data that has low value for his/hers work. Actual user of the data is in operations or logistics.

Empirical material of this study emphasized the significance of product structure's effect on PDON, especially towards data ownerships. Product structure can be defined through data elements, which describes a certain products component, element, module, subsystem or assembly which all needs to be handled and owned through PDON.

In every enterprise, there has to be an unambiguous specific quarter, which defines and leads the building and monitoring of PDON. These manners don't just happen by themselves. Enterprise has to set up a dedicated group that works in closely with different business, operation and technology groups in order to successfully implement PDON. This quarter has to ensure that all the roles, functions and processes of PDON are commensurate as enterprise-wide wholeness. Figure 3 presents a simplified illustration of PDON's definition process.

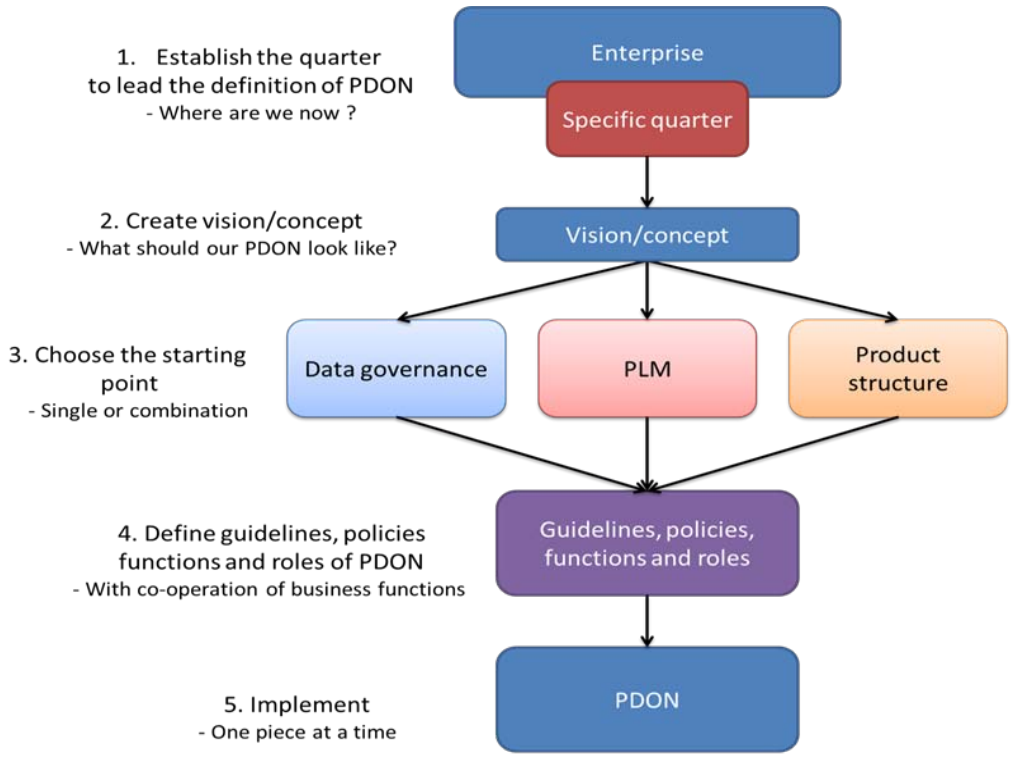

Figure 3: A Simplified PDON definition process.

Implementing PDON

Enterprise architecture model can be seen as a tool to define and develop enterprise's data related functions further. Although EA model is used to develop the whole enterprise, this research focuses on the information architecture discipline. The scope of information architecture is to define the enterprise's essential product data, assign the ownerships of product data and to describe the exchange of product data between different stakeholders. The results occurring from the work of information architecture work can be used as basis when defining and building PDON.

PDON model proposed in this paper is general and should be used as guideline when implementing in enterprises. It should also be mentioned that enterprise-specific customization of this model to meet the enterprises demands is recommended.

The biggest challenge concerning the building and implementation of PDON is the upper level management. Getting upper level management excited about product data and further about PDON is crucial. Without given resources and investments (financial and manpower) in product data and related functions, the efforts for building PDON are pointless. Because poor product data quality affects both the operational and the strategic sides of business, addressing PDON takes a strategic importance that must be validated by the participation of the management of the business. Easiest way of getting upper level management excited about product data is to present facts of financial losses from enterprise's history that were caused by data problems.

It has to be mentioned here that establishing PDON, ensuring data quality and making product data management functional is not done by overnight. These manners have to be seen as long-term processes, which are divided into intermediate goals. Changes and development in processes, protocols and functions always confront resistance that needs to be persuaded to approve changes in the long run. Developing these manners little by little eases this workload.

CONCLUSIONS

Eventough enterprises invest in IT, the return of the investment does not meet the expectations. This can be seen as higher operational costs. It is very often that IT projects go over their budgets or after the go live there are serious operational challenges within the enterprise. All these are caused by the fact that systems are getting more complicated with automation and this adds the need of high quality data. Data is used to master the functionalities within the systems. Data is owned by the business organisations and specially data owners. This job is often additional task to perform and one can only meet the expected quality level if the role descriptions are instructions are in place, trained and maintained.

Product data is the most complex master data element and was selected because of that. Making the data ownership visible within the enterprise, makes the cross-functional co-operation easier. To identify how this should be done in practise, this research focuses to discover the key elements and requirements of PDON.

Product data needs to be distributed, maintained and its quality ensured. PDON includes several practices and processes to support and operate these activities. Besides the actual *definition of PDON*, which includes definitions of guidelines, policies, roles, responsibilities and all the product data related functions, the main function of PDON is the *ensuring data quality*. The responsibility of product data quality is assigned to the data owners in the end but other roles and functions has also the responsibility to support data owners by monitoring and making corrective actions towards product data.

Making product data available for those needing it is crucial. Lack of critical part of product data can intercept enterprises' business processes. Therefore product data needs to be made available for those needing it through product data sharing and distribution practices. There are also commonly made changes to the product and its related data during the product lifecycle. There have to be effective *change management process* which is based on *traceability* of the responsible data owners and other responsible concerning those certain parts of the product. PDON should also be used as *supporting network.* As people always will confront difficulties in their daily tasks, there should be a quick way to receive support and assistance.

Clearly an area that needs to be further studied is how much the product type (tangible vs. intangible product or mixture of these) has influence to the functions and structure of PDON. This research was mainly concentrating on tangible products and PDON build around those. The product structure of tangible product can be constructed straightforward and as this study

pointed out, it has major effect towards PDON's structure. Product structure of intangible products is not relatively different from tangible product but the data content and product lifecycle are making the difference. Furthermore managing intangible product through PLM and PDM and intangible product's productization are still quite untouched topics in the literature. Therefore its effects to usefulness towards PDON should be studied.

During the interviews made for the empirical research part of this study, two further research topics came up and are opened here as they clearly are elements that have a big impact on PDON implementation.

1. Terminology of PDM, PLM and PDON area is still quite a mess. Many of the specialists emphasized that the terminology of these manners should be generalized in order to have common understanding between enterprises and specialists. The terminology is not competitive advantage of any enterprise and therefore the basis of it could be generalized.
2. Biggest bottleneck concerning the establishment of PDON was the upper level management and their ignorance and lack of understanding of product data related issues. In other words, business change management practices have to be understood within the enterprise. This is to be able to provide unambiguous proof about the benefits (financial and efficiency) of PDON and the product data management related functions, establishing and driving PDON and other data related functions would be much easier in enterprises.

Both topics raised here do require real life pilots of the PDON in different scale of companies and product categories (tangible vs. intangible). Biggest challenge of all is the tendency of enterprises to require fast results and lack of the business change management.. The Importance of good data is rising as the need of business intelligence demand increases. Also new starting IT projects in enterprises seems to have dedicated data management parts where PDON and related issues are been considered. Social media applications provide good supporting tools to manage PDON networks after they have been implemented beside of the product process management.

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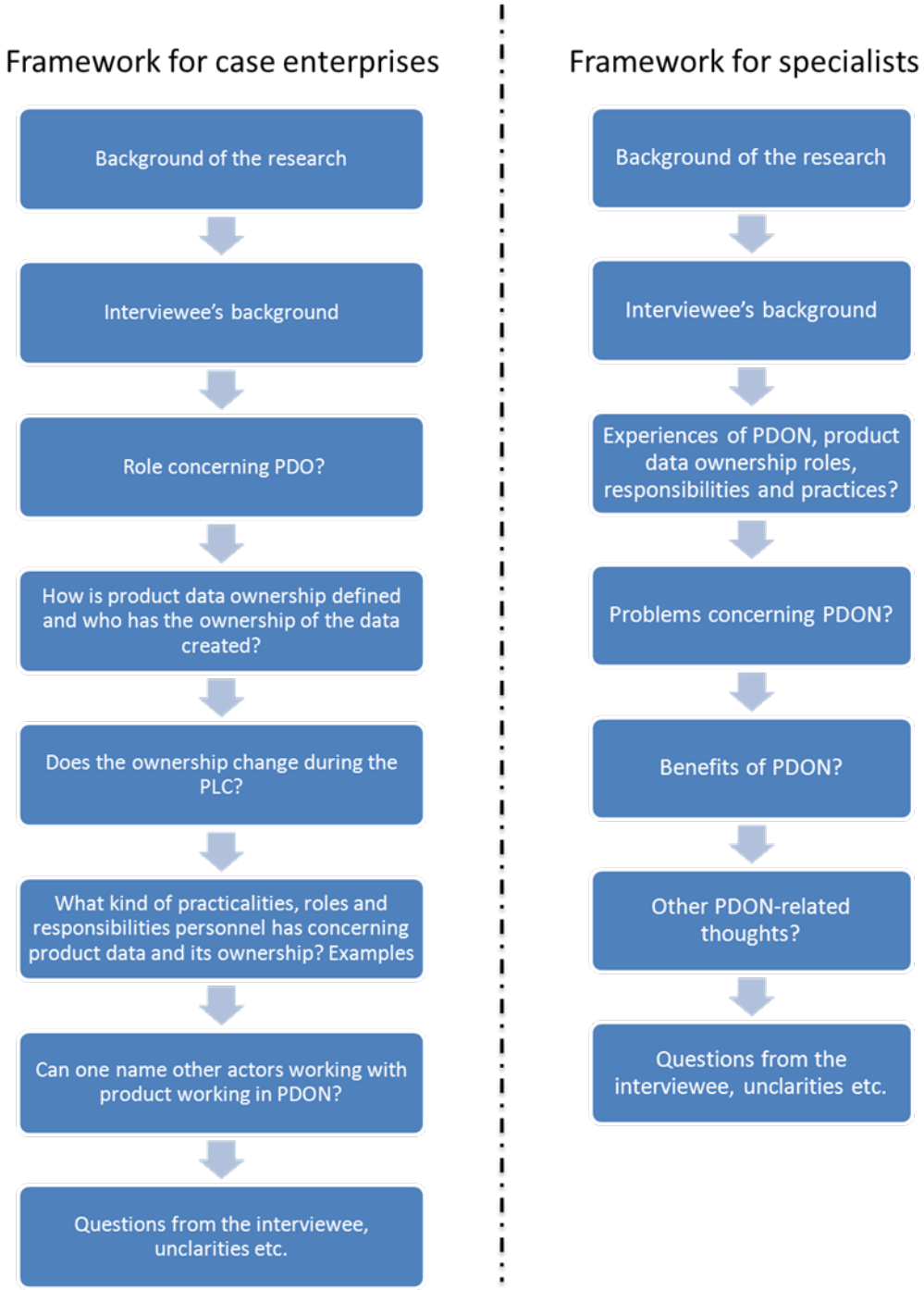
APPENDIX 1

Question frameworks



LIFECYCLE VIEW ON PRODUCT DATA QUALITY DIMENSIONS

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ABSTRACT

This paper discusses about the data quality dimensions and is related to general field of product data management research. Data quality dimensions are metrics, which can be set to measure data quality characteristics more precisely. In this research, data quality dimensions are investigated from the organisational point of view; how organisational function affects on the experienced importance of data quality dimensions. The results reveal that the most important data quality dimensions are "accuracy" and "accessibility", when viewing summarized results from each organisation function. But when results are viewed individually at organisation function level, we can see that there are differencies. The purpose of the data usage in organisational unit affect on the importance of different dimensions. The results founded here fortify the earlier research data quality needs to be considered together with the data usage. Also, this study provides new information as similar research concentrating on data quality in organizational functions has not been conducted before. What these results mean in practise is that data quality, and how it will be evaluated, need to be considered together with the data users, as they understood the actual use of the data. Data quality measurement alone can be meaningless if not tied up with the real data usage.

Keywords: Data quality, product data, product data management

INTRODUCTION

The amount of data is growing increasingly fast forcing organizations to invest on different technologies to collect, store and process the data (Madnic and Wang, 2009). Organization databases can grow up to 50% per year meaning more information to manage business (Valentine, 2010). However, the data needs to be high quality to benefit the business; otherwise data turns to pollution that may harm the company and its environment.

Therefore, data quality is gaining more attention when organizations are realizing that data quality issues cause losses in money, time and in missed business opportunities (Olson, 2003). According to Piprani and Ernst (2008), the reasons behind the overall poor data quality can be pinpointed to a lack of supporting business processes, insufficient analysis techniques, and methods of assessing incoming data quality. To improve these aspects the area of data quality management has absorbed practices from the product quality

management, from Six Sigma and Total Quality Management (Wang, 1998; Redman, 2001). Typical statement for these quality methods is that "you can't manage what you can't measure." This is also true for data quality management.

Measuring data quality is more difficult than a measuring product quality since the data is more abstract concept (Wang, 1998). To define what data quality is and how to measure it, academic researchers have divided data quality into smaller sub-sections; data quality dimensions. Depending on the research, there are typically 4-20 dimensions to be used for data quality measurements (e.g. Wand and Wang, 1996; Freiden et al., 1998; Wang, 1998; Kahn et al. 2002; Piprani and Ernst, 2008; Herzog et al., 2007; Batini et al., 2009; Herrala et al., 2010; Cappiello et al., 2010).

Data quality has been studied widely and in different point of views during the last decades. Massachusetts Institute of Technology (MIT) has been a pioneer on data quality research since Total Data Quality Management (TDQM) program was started 1992. (Madnick and Wang, 2009.) Despite the significant amount of research, there is still no accurate and unanimous definition what data quality exactly is. In general, data quality is understood as "fitness-for-use", meaning how well data can be used for different purposes. (Wand and Wang, 1996; Madnick and Wang, 2009). There are no commonly agreed definitions for data quality dimensions either.

In the earlier research, data quality dimensions are handled as general indicators without considering the actual use of the data. This study approach the product data quality from the organization functions point of view and investigates how the importance of product data quality dimensions is perceived in different organization's functions (product development, manufacturing, sales & marketing, service & maintenance and product data management). Product data is referred as data broadly related to a product and it is a very significant research topic since it ensures that a company manufactures, delivers, sells, and maintains correct products. This research can be summarized into the following research questions:

RQ1. What are the most important product data quality dimensions during the order-delivery process?

RQ2. Does the organisation affect on the importance of the data quality dimensions?

In context of data quality, there are two terms which are generally used; data and information. Data means raw data, such as results from measurements, and information is understood as processed data. Data quality might also refer to technical aspects and information quality to nontechnical aspects (Madnick and Wang, 2009). In many cases these two terms are used as interchangeably and if not mention separately, the same applies also for this paper.

DATA QUALITY: DATA TYPES AND DIMENSIONS

Different data types

In general, data can be classified in three types: 1. Structured data (e.g. statistical data, tables), 2. Unstructured data (e.g. generic sequence of symbols, free text) and 3. Semi structured data (e.g. XML mark-up language). As data loses structure the data quality techniques becomes more complex. The quality dimensions may have different metrics depending of the types of data. (Batini et al., 2009).

Product data, which is generated during product development, is often unstructured. According to Contero et al. (2002), typical PDM (product data management) system contains two kinds of data: product data (geometry, digital mock-up, analysis and simulation results, materials, reports) and process data (manufacturing engineering data, planning and machining data, plant layouts). Quality of product data is very important especially in concurrent engineering.

General definition for product data is often linked to product design or development. Phelps (1998) defines product data quality as "Product data quality is a measure of the accuracy and appropriateness of product data combined with the timeliness with which those data are provided to all the people who need it". Contero et al. (2002) presents three levels of product data quality:

1. *Morphological – relates the geometrical and topological correctness of the CAD model*
2. *Syntactic – evaluates the use of the proper modelling conventions*
3. *Semantic/pragmatic – considers the CAD model capability for reusing and modification*

ERP data is logical continuum for product data. Haug et al. (2009) claim that ERP systems handle two kinds of data: master data and transactional data. Master data contains the basic instances of business entities and transactional data describes the relevant events in a company. They discuss the different definitions of data quality dimensions and conclude that for ERP data, quality dimensions are:

1. *Intrinsic data quality dimensions: completeness, unambiguousness, meaningfulness, and correctness*
2. *Data accessibility dimensions: access rights, storage in ERP system, representation barriers.*
3. *Data usefulness dimensions: relevance, value adding*.

Xu et al. (2002) state that "data quality problems are one of the major reasons organizations implement an ERP". ERP systems integrate separate sub-systems, which caused intrinsic, accessibility and contextual data quality problems. However, ERP system may also worsen the data quality issues since the same data is used in different modules. To sum up the previous chapters, it can be concluded that data type and structure needs to be considered when planning data quality measurement.

Measuring data quality

Data quality can be categorised and measured with different dimensions and metrics. Wang and Strong (1996) have defined data quality dimensions as "a set of data quality attributes that represent a single aspect or construct of data quality". Dimension, such as accuracy, reliability or completeness, may contain several metrics. For example, dimension accessibility is measured with metrics: is data easily retrievable, is data easily accessible, is data easily obtainable and is data quickly accessible when needed (Lee et al., 2002). There are no common definitions and companies are creating dimensions and metrics for ad-hoc needs.

Most data quality dimensions and metrics refer to data values, such as customer data (name, address or date of birth). Dimensions can refer also to data schemas but those are rarely used. (Batini et al., 2009.) Many authors have presented different data quality dimensions lists. According to Wand and Wang (1996), dimensions are selected and created based on intuitive understanding, industrial experience or literature reviews. Table 1 summarises data quality dimensions and definitions gathered from the literature review (Wand and Wang, 1996; Freiden et al., 1998; Wang, 1998; Kahn et al. 2002; Piprani and Ernst, 2008; Herzog et al., 2007; Batini et al., 2009; Herrala et al., 2010; Cappiello et al., 2010).

According to Piprani and Ernst (2008) it is essential to be able to assess data quality across both the earlier and later stages of the product development lifecycle from any given point. The data quality cannot be evaluated independent of the people who use the data (Strong et al., 1997) and the way how stakeholders perceive the data quality affects their behaviour and decisions (Pipino et al., 2002).

Table 1: Data quality dimensions and definitions.

Dimensions & metrics	**Definitions**
Accessibility	The extent to which data is available, or easily and quickly retrievable
Accuracy	Inaccuracy represents a real-world state different from the one that should have been represented
Applicability	Number of orphaned pages
Appropriate amount of data	The extent to which the volume of data is appropriate for the task at hand
Availability	Refers to possible access limitations, such as component licences define
Believability	The extent to which data is regarded as true and credible
Comparability	How two or more databases can be compared
Completeness	The extent to which data is not missing and is of sufficient breadth and depth for the task at hand
Concise representation	The extent to which data is compactly represented
Consistent representation	The extent to which data is presented in the same format
Consistency	Refers to values and the representation of data
Contents	How attractive content is to the user
Convenience	Difficult navigation paths: number of lost/interrupted navigation trails
Credibility	Number of tuples with default values
Currency	The time data item was stored
Derivation integrity	Percentage of correct calculations of derived data according to the derivation formula or calculation definition
Ease of manipulation	The extent which data is easy to manipulate and apply for different tasks
Effectiveness	Effectiveness means the effect information has on the user
Form	Refers how information is made available to the user
Free-of-error	The extent to which data is correct and reliable
Functionality	Aggregation of interoperability, compliance, and security
Interpretability	The extent to which data is appropriate languages, symbols, and units, and the definitions are clear
Maintainability	Number of pages with missing meta-information
Objectivity	The extent to which data is unbiased, unprejudiced, and impartial
Precision	Lack of precision is typically viewed as inaccuracy
Presentation usability	The usability of presentation mechanism
Relevancy	The extent to which data is applicable and helpful for the task at hand
Reliability	Correctness of data in our systems
Reputation	The extent to which data is highly regarded in terms of its source or content
Security	The extent to which access to data is restricted appropriately to maintain its security
Speed	Server and network response time
Temporal relatability	Meanings and semantics that can change over time
Timeliness	The extent to which the data is sufficiently up-to-date for the task at hand
Understandability	The extent to which data is easily comprehended
Uniqueness	Data values that are constrained to a set of distinct entries - each values being the only one of its kind
Validity	Conformance of data values that are edited for acceptability - reducing the probability of error
Value-added	The extent to which data is beneficial and provides advantages from its use

Volatility	Time length for which data remains valid

Although Table 1 lists over thirty differently named dimensions, they are partly overlapping. For this research, the following dimensions have been selected: Accuracy, Completeness, Timeliness, Accessibility, Validity and Relevance. The selection is based on how often the dimensions are mentioned in the literature, and then how well the dimensions illustrate the different data quality properties for data handled in different organisation's functions (e.g. Piprani and Ernst, 2008; Herzog et al., 2007; Ravn and Hoedholt, 2009; Wang and Strong, 1996; Lucas, 2010).

RESEARCH PROCESS

Figure 1 illustrates the research process applied in this study. This study addresses the research questions in a qualitative and quantitative manner, through literature review and industry questionnaire. At first, literature review was made to gain proper understanding over current data quality research. The main focus was on data quality dimensions. Based on literature review, the most significant dimensions were selected for the study and the questionnaire was created.

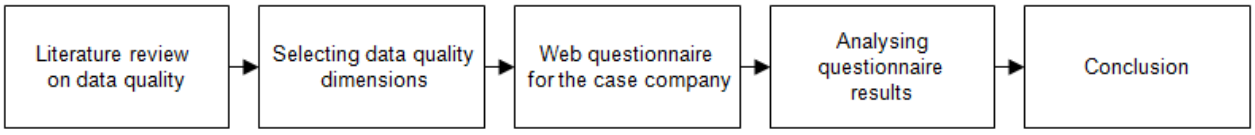

Figure 1: Research process.

The interview questionnaire included open ended questions and pairwise comparisons section. A pairwise comparison is a part of analytical hierarchy process -method, which can be used to rank a set of alternatives (in this case, the importance of data quality dimensions). Pair-wise comparison gives more accurate results, as only 2 items are compared at time (e.g. which one is more important dimension: accuracy or completeness, instead of listing all the dimensions and asking the person to rank all the listed items in descending order of importance).

The interview questionnaire was implemented as a web-application. The invitation letter and link to the web questionnaire was sent to the contact person from the case company, and the person was asked to forward the research to the data consumers from different organisations. Large companies are interesting research targets for data management and data quality research, as the challenges are more complex but also the benefits gained are more meaningful. The case company in this study is one of the leaders of its industry (large machining products and solutions), working globally and had billion class net sales in 2010. Employees from the departments (i.e. functions) of product development, manufacturing, sales & marketing, after sales, product data management and participated the research. Also, there were some answers, which could not be categorized under mentioned organisations. In the next chapter, the results are presented in more detail.

RESULTS AND DISCUSSION

Results from the case company

Altogether 27 answers were received from the case company. The answers were sorted into groups of "Product development", "Manufacturing", "Sales & Marketing", "Service & Maintenance" and "Product data management", based on what kind of product data the answerers need in their daily work or in which organizational department they work in. The results represented here are summarized from the open ended questions and pairwise comparisons.

Bar charts (Figures 2, 3, 4, 5 and 6) represent the importance factors of different data quality dimensions. The importance order of the different dimensions can be read from the charts but it also reveals the respective relations between different dimensions.

Product development

The data needed in product development organisation is very technical in general but also customer requirements data is needed. The leading manager of the technical product development concluded "*Product data that genuinely serves the organization or customer in some phase of the product lifecycle is the most important. Everything else is unnecessary and loads the employees for nothing*". It was said that "*Quality product data is easily readable and can be trusted. Employees are interest of it.* High quality product data "*makes daily work faster and easier, and increases work convenience*". In the product development organisation the downsides of poor data quality was clear seen: "*Bad or incomplete product data slows out work and decreases the overall reliability of product development*". The figure 2 presents the results of the data quality importance questionnaire from the product development organization.

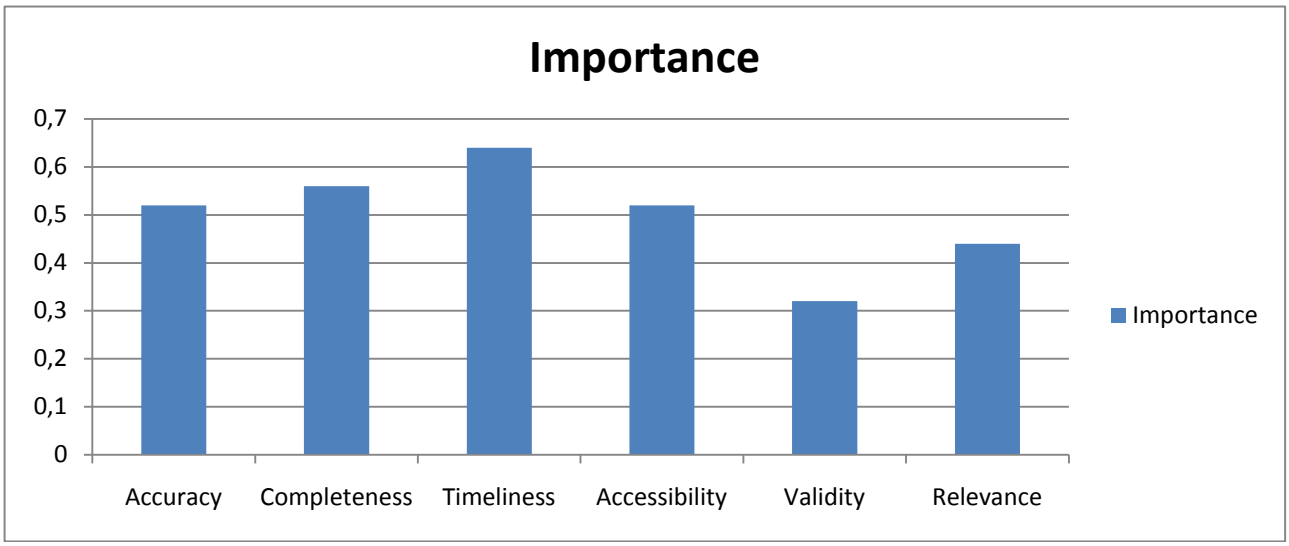

Figure 2: Importance of data quality dimensions in product development organisation.

Manufacturing

The manufacturing organisation needs product data for manufacturing products. The most important types of product data are: manufacturing documents and guidelines, drawings, traceability data, test data and change management data. Data quality means that data is "*correct and accurate, and available when needed". "The data needs to be easily accessible, in exact form and easily shared forward".* Figure 3 presents the result from the manufacturing organisation.

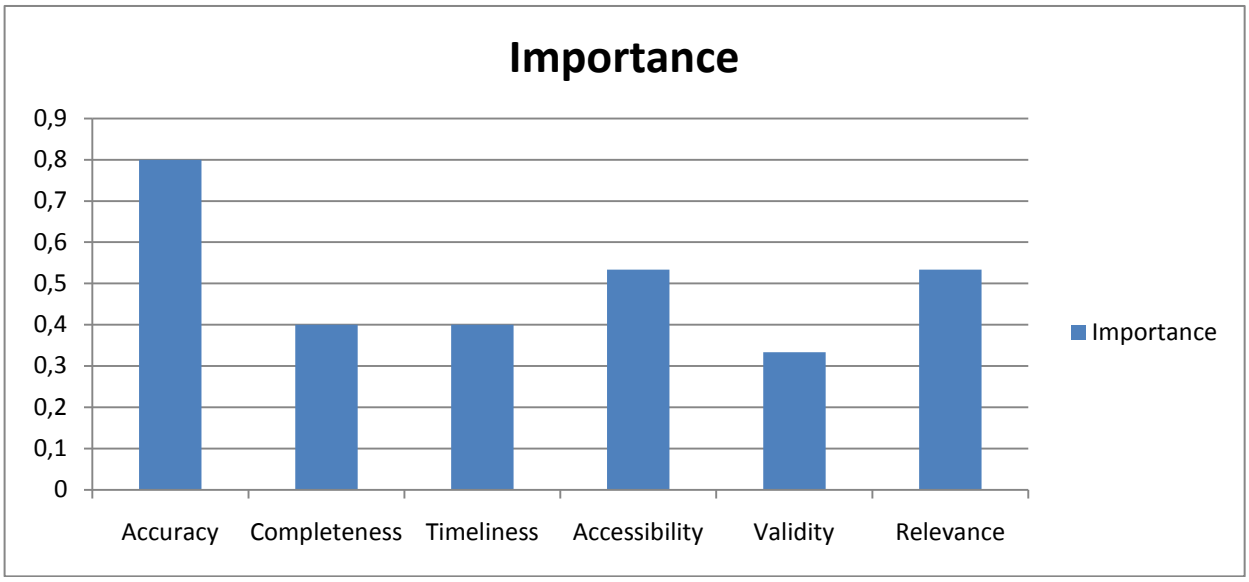

Figure 3: Importance of data quality dimensions in manufacturing organisation.

Sales & Marketing

The product data needed in sales & marketing organization is general on its nature, varying from customer data to technical information. Drawings, quality documents and product certifications are also often needed product data in sales & marketing. The quality of product data is understood as "*accuracy, in a way, that sales and purchasing pass through the systems without difficulties*". It was also said that *"data needs to be consistent – the data and the drawings need to tell the same information".* Another important dimension for the data quality seems to be the accessibility: "*The product data needs to be available all the time, also when working out of office, for example in customer's office*". Accessibility is important dimensions for the customers also, "*From the customer perspective, the data quality needs to high level, that data is easily founded and it has no errors".* The results from the S&M pair-wise comparisons are presented in figure 4.

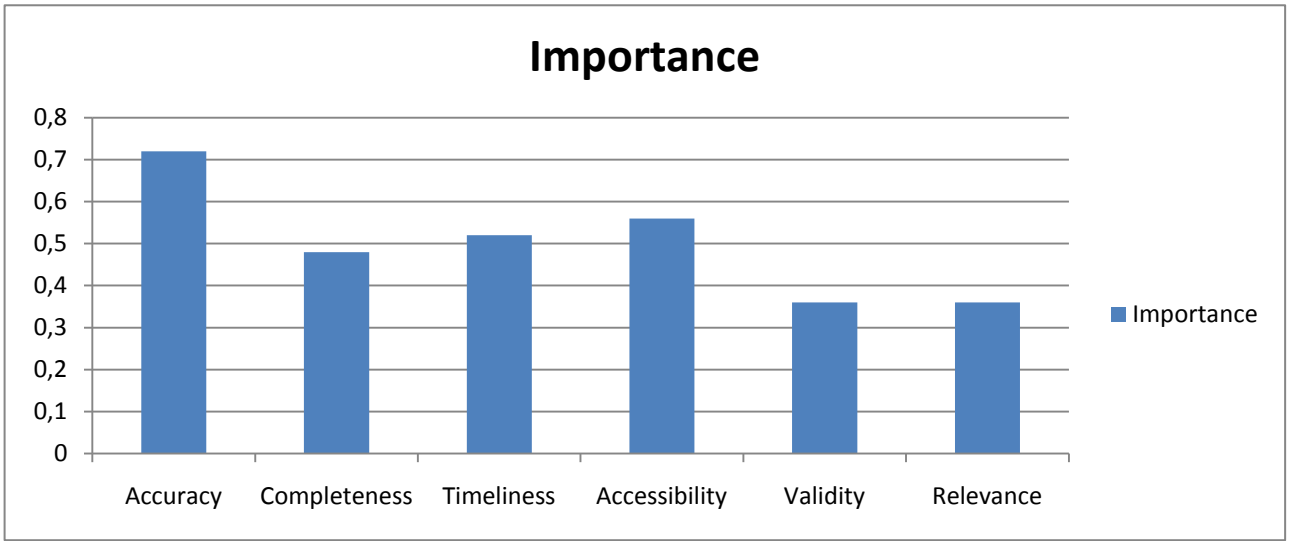

Figure 4: Importance of data quality dimensions in Sales & Marketing organisation.

Service & Maintenance

Service and Maintenance needs the product data to manage the spare parts information and the service business. Therefore, the most important product data are product related master data and technical data, such as product's technical properties, type markings, and what parts are used in which assembly. In sense of data quality, this means that data needs to be accurate. It is also needed that "*data is correct, up-to-date, and saved in correct fields*". "*The data needs to be accurate and in correct form*". In Service & Maintenance organisation, it was stated many times that data needs to up-to-date. The results from the Service & Maintenance pair-wise comparisons are presented in figure 5.

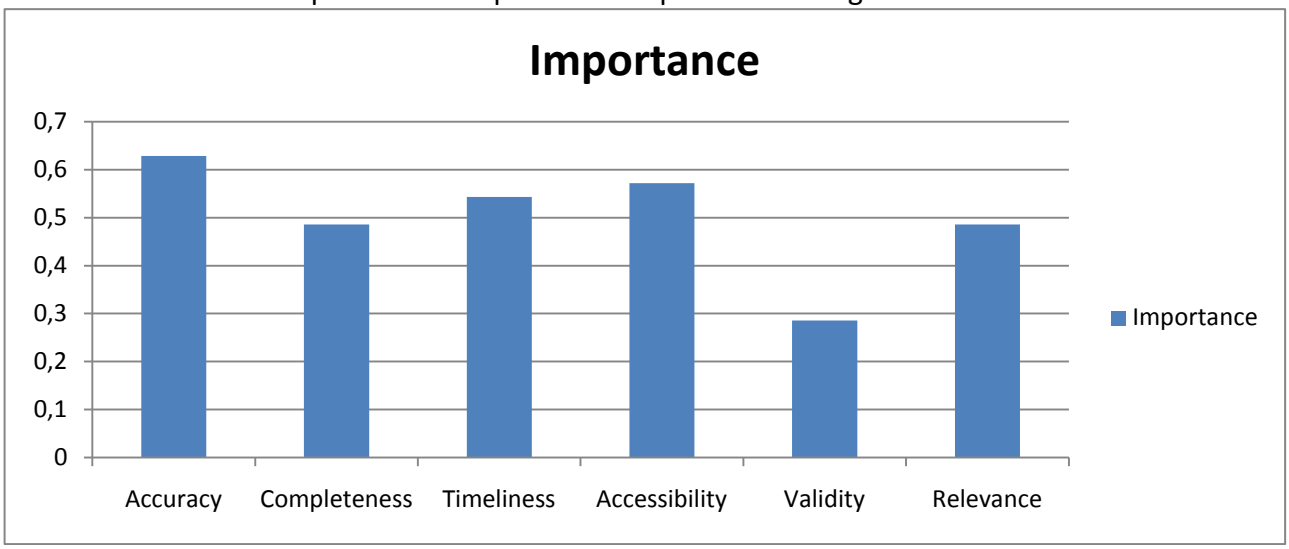

Figure 5: Importance of data quality dimensions in Service & Maintenance organisation.

Product data management

Product data management organisation is more supporting organisation than a traditional order-delivery organisation. However, people from the product data organisation may have the best view over product data as a whole, as they need view it more than one perspective, making it interesting research target.

Representative tasks of product data management are management of wide entities, such as product structure or combining different product data from many sources. They are also involved, when defining data management practices.

In PDM organisation, all product data in general was considered as equally important. "*The importance of data quality dimensions is defined by the business needs*". Accessibility dimension stood up as a most important data quality dimension and it was said that "*The data must be: easily accessed and divided into logical entities, no unnecessary data, data is in understandable form for its user and no special administrator rights are needed to use the data*". "*It is important to create and maintain correct data, which is relevant for business*", "*correct products with relevant product data in right place at right time*". The results from the Product data management organisations are presented in figure 6.

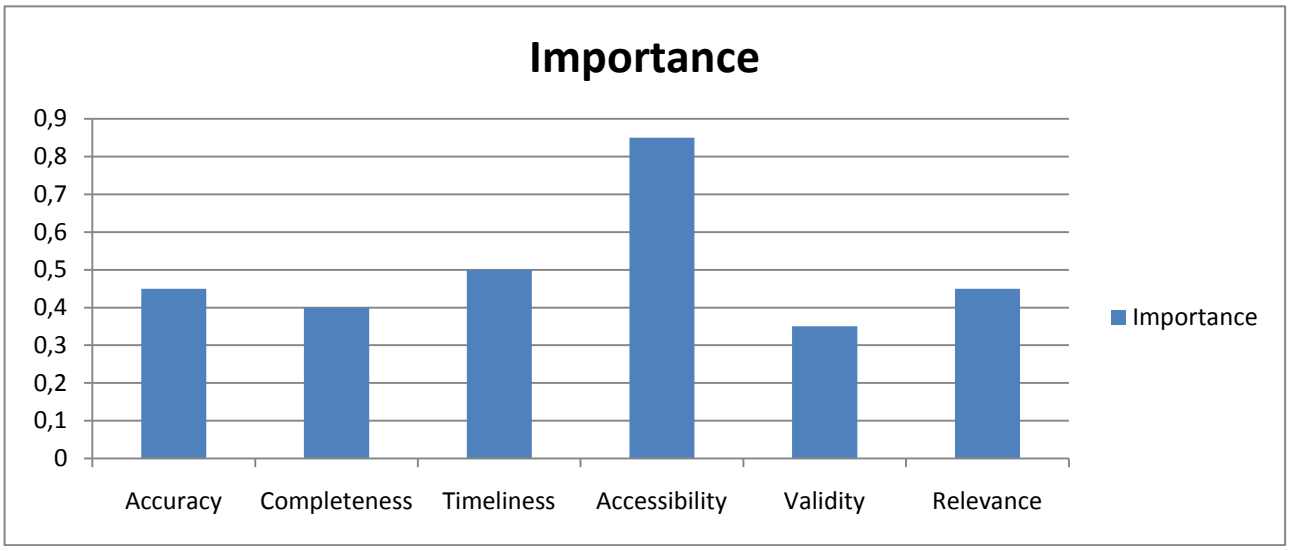

Figure 6: Importance of data quality dimensions in Documentation & PDM organisation.

Entire organisation

Figure 7 presents combined results from the entire company. It includes the results presented in earlier sections but also the results that could not be categorized under those organisations. These results are presented for comparing purposes.

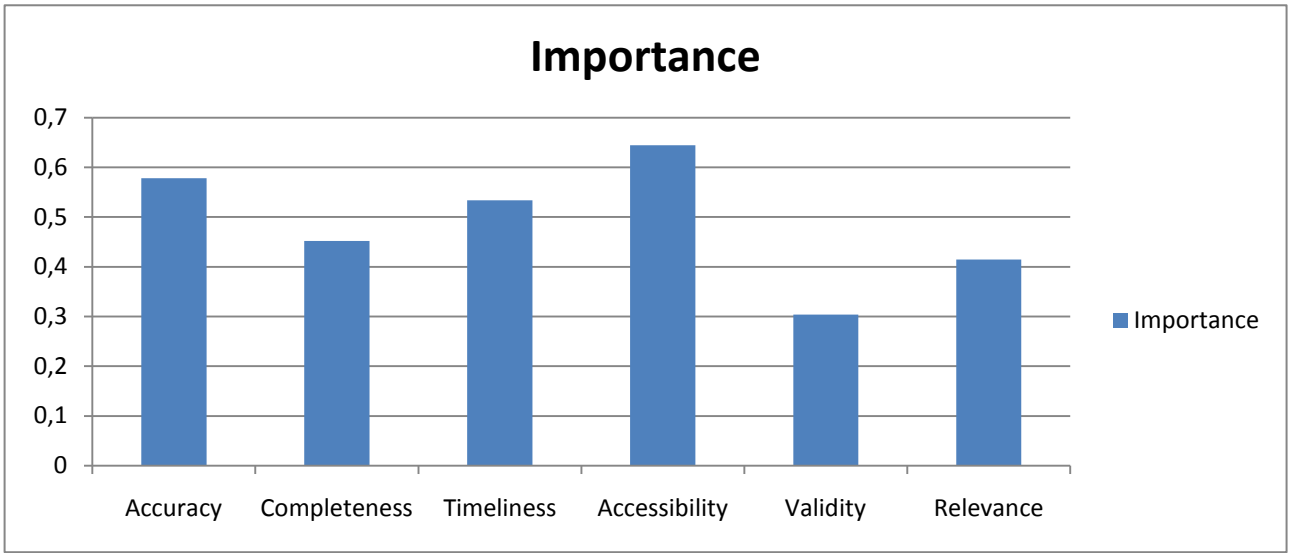

Figure 7: Importance of data quality dimensions in entire organisation.

Discussion

The results indicates that different organisation have different needs for data quality. For example, data users from product development prioritized "timeliness" as the most important data quality dimension for them. It can be explained with the need for the latest customer requirements, which is vital for successful product development.

Manufacturing organisation assigned "accuracy" as the most important dimension, which can be explained with the need for unambiguous manufacturing documents and guidelines. Also, the "accuracy" was considered almost twice as important as the next important dimensions "accessibility" and "relevance". This highlights the importance of "accuracy" for the manufacturing organisation.

In Sales & marketing, the "accuracy" dimensions stood up as the most important dimensions. "Completeness", "timeliness" and "accessibility" were the next important dimensions. Typically, S&M needs accurate and up-to-date information about products to market the up-coming products.

In Service & Maintenance, the importance of the different dimensions were most equal, expect the "validity", which was considered as the least important dimension. Also, there were no stereotypical statements to explain any differences.

Product management organisation considered all data equally important, which suits for the role commonly set upon PDM, as a supervisor of all data. In that sense "accessibility" as a most important dimension is a reasonable result.

Although the result represented here points out that different organisations have different needs for data quality, the sample size per each organisation is too small to be statistically significant. However, this study verifies the earlier research which state that importance of data quality depends on the data user and data usage. It also strengthens the view of data

quality as “fitness-for-use”, meaning that the data needs to be understood first, before any meaningful data quality measurement can be placed.

CONCLUSIONS

Data quality dimensions are metrics, which can be set to measure data quality characteristics more precisely. The most often used dimensions are “accuracy”, “completeness”, “timeliness” and “accessibility”. Companies can also set up their own dimensions for their needs. In this research, it was studied: *(RQ1) What are the most important product data quality dimensions during the order-delivery process?* and *(RQ2) Does the organisation affect on the importance of the data quality dimensions?*.

The results reveal that “accuracy” and “accessibility” are the two most important dimensions during the order-delivery process. However, the importance of the dimensions varies depending of the organisation. It seems that the purpose of which data is used have an effect on the importance of the dimensions. Typically, if organisation needs exact data (such as manufacturing documents in manufacturing organisation) then the accuracy is considered as most important dimensions.

What these results can mean in practise is that data quality needs to be considered together with the data users, as they understood the actual use of the data. Data quality measurement alone can be meaningless if not tied up with the real data usage. Therefore, it is not wise to build data quality capability from the outside of the organisation, since the data and its purpose need to be understood. This is especially in case of product data, which is often semi- or unstructured, and can be very technical requiring specific expertise to able to validate the data.

These result offer interesting view on data quality dimensions in different organisation’s functions, revealing what are the data quality dimensions that matter the most in different phases of product lifecycle. This is also new information as corresponding research has not been made earlier.

This research included results only from one company. It would be beneficial to conduct the study in several companies and see how it affects to the results. Additionally, this research studied a company, which produces tangible products. Another part of the research could study what are the most important data quality dimensions when dealing with services or software products.

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C2 – Sourcing

C2.1 **A consumer driven business model's impact on sourcing and inventory**
David Eriksson

C2.2 **Development of a dynamic strategic purchasing management model for a project oriented global high tech company**
Pirjo Janhunen

C2.3 **Facilitating internationalisation through trade fairs: Case China**
Miika Kreivi

C2.4 **Managing sourcing process with Chinese suppliers – A case study of Finnish companies**
Dr. Lingyun Wan

C2.5 **Sourcing from China - perspectives from Finnish SMES**
Matti Muhos

A CONSUMER DRIVEN BUSSINESS MODEL'S IMPACT ON SOURCING AND INVENTORY

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ABSTRACT

Increased competition in many markets has forced firms to adopt new business models. One way to differentiate from the competition is to develop products based on implicit consumer needs that may be sold at a premium price. This research uses case study methodology to investigate a Swedish furniture wholesaler, and how their shift to a consumer driven business model has affected sourcing and inventory. The research reveals that the high focus on the demand-side of the company has had detrimental effect on the supply-side. Between 2004 and 2009 the number of stock keeping units increased dramatically, and the sales increased with 22%. Sourcing was affected since the order quantities became smaller, which lead to longer lead times in manufacturing. The inventory levels also increased, as did the average inventory turnover. As the market dropped in 2008 due to the economical situation, the case company was not able to respond to the changes in demand. The main theoretical implication is that the management of the demand- and the supply-side of the firm have to be coordinated on macro level, the main practical implication is that managers needs to devote time to both management directions, and the main social implication is that differentiated supply chain strategies may employ people closer to the consumption market.

Keywords: Consumer driven, sourcing, inventory, furniture,

INTRODUCTION

During recent decades a new market has evolved to co-exist with the conventional low-cost market. The new market is characterized by rapid and volatile demand changes, short product life cycles, and a high degree of customized products. Companies that want to be competitive in this market need to focus on the needs of the consumers rather than the technology of their products (Christopher et al., 2004). As a result of increased consumer sensitivity consumers have gained power to influence supply chain activities (Leonard and Sesser, 1982; Takuechi et al., 1982). One example of consumers' impact is found in the drug industry as consumer networks' word of mouth became more important than the claimed benefits of the drug (Prahalad and Ramaswamy, 2004). The quest for superior products, however, requires supply chain capabilities that can supply the products (Canever et al., 2008; Hilletofth, 2009; Jüttner et al., 2007; Walters, 2008).

Parallel to the evolution of the marketplace, globalization has changed worldwide business dynamics. Reduction of trade barriers, progress in information technology, and improved transportation infrastructure has facilitated a landscape for global operations (Hilletofth et

al., 2007). Countries are no longer isolated entities, but parts of a global trade system (Dreher, 2006). As an attempt to decrease costs and improve competitiveness companies outsource business areas to low-cost countries (Christopher, 2000). The result is complex, world spanning supply chains (Cavinato, 2004). Global supply chains do not only increase geographical distances, but also cultural distances, impairing collaboration (Lowson, 2001; Lowson, 2004, Warburton and Stratton, 2002).

Companies that enter into a consumer driven market environment needs to manage the new market, and the complexity of global sourcing. Activities dedicated to understanding, creating, and stimulating consumer demand is managed with demand chain management (DCM) (Charlebois, 2008; Hilletofth, 2011; Jüttner et al., 2007; Walters and Rainbird, 2004), and supply chain management (SCM) is a set of activities dedicated to the management of supply processes (Gibson et al., 2005; Lummus and Vokurka, 1999; Mentzer et al., 2001). Even though DCM and SCM are of vital importance to all organizations there is a tendency to manage them on micro level, often giving one priority over the other (Hilletofth el al., 2009).

This research investigates a small Swedish furniture wholesaler (Alpha) and how their consumer driven business model has impacted their sourcing, and inventory. In an attempt to differentiate from its competition, Alpha took a strategic decision in 2004 to change their business model. Alpha changed from competing on lowest price, to compete in a premium price range offering added value to their consumers, i.e. from cost driven, to demand driven. The change in business model was primarily focused on DCM capabilities, which has resulted in several innovative furniture solutions, but SCM was given equal attention. The purpose of this research is to investigate how a DCM focused business model affects SCM, more specific sourcing and inventory. The research question is: “How are sourcing and inventory affected by a demand led business model?” The question is investigated through a literature review, and a case study.

The remainder of this paper is organized as follows. In Section 2 a literature review is presented, in Section 3 the research methodology is presented, in Section 4 case study findings are presented, and Section 5 is a concluding discussion.

LITERATURE REVIEW

Since companies give DCM and SCM unequal attention, it is possible to distinguish demand led and supply led organizations in most industries (Jüttner et al., 2007; Lee, 2001; Piercy, 2002). DCM activities include market intelligence, new product development (NPD), branding, and marketing and sales, SCM activities include sourcing, manufacturing, and distribution (Hilletofth, 2011). Demand chain masters focus on product differentiation, and premium brands and products, and supply chain masters focus on cost reduction (Jüttner et al., 2007). If one management direction is over emphasized it may lead to major difficulties (Walters, 2008). Demand chain activities that not have supply chain support can result in increased costs, and inefficient product delivery, while supply chain activities that lack demand chain support can harm new product development (NPD), cause poor segmentation, and reduce efficiency in product delivery (Jüttner et al, 2007; Piercy, 2002).

It has been proposed that coordination between DCM and SCM should be assigned to either DCM or SCM (Mentzer el al., 2001; Srivastava et al., 1999; Williams et al., 2002), or that DCM and SCM should be coordinated on macro level (Canever et al., 2008; Hilletofth et al., 2009). The latter is called demand-supply chain management (Hilletofth, 2011) and strives to provide superior value, while minimizing costs (Hilletofth et al., 2009; Jüttner et al., 2007; Walters and Rainbird, 2004). DSCM suggests that DCM and SCM should be aligned, and that they require equal attention (Hilletofth et al., 2010; Jacobs, 2006; Jüttner et al., 2007, Rainbird, 2004). Management may be separated into three levels: long-term strategic decisions regarding structure and design of the chain, medium-term tactical decisions regarding planning of the chain, and short-term executional decisions regarding operation of the chain.

Demand and supply processes are closely related (Eriksson and Hilletofth, 2011; Hilletofth and Eriksson, 2011). Product design, for example, may have an impact on the supply chain performance, but the configuration of the supply chain may help to improve the NPD process (Van Hoek and Chapman, 2006). Cost-efficient creation of superior consumer value relies on: consumer focus in demand and supply processes (De Treville et al., 2004; Heikkilä, 2002; Hilletofth et al., 2009), coordinating value creation and delivery (Canever et al., 2008; Esper et al., 2010; Jüttner et al., 2007; Walters and Rainbird, 2004), a view that demand and supply processes are equally important and manage them in a coordinated manner (Hilletofth et al., 2009; Jacobs, 2006; Langabeer and Rose, 2004; Rainbird, 2004; Walters, 2008), and considering value creation in both demand and supply processes (Hilletofth et al., 2009; Vollmann and Cardon, 1998; Walters, 2008).

One of the most critical DCM processes is NPD, which includes all activities required to present a new or modified product to the market (Cooper et al., 2004; Rogers et al., 2004). The main objective on NPD is to develop products with new of different characteristics as quickly and cost-efficient as possible (Kotler et al., 2009). NPD may result in new products, or upgrades of existing products (Kärkkäinen et al., 2001; Perks et al., 2005). Successful companies develop a holistic NPD process that utilizes a stage gate system (Cooper, 1990). A stage gate system is a process consisting of several stages where the end of each stage is a gate or a checkpoint (Kotler et al., 2009). Empathic design is a technique that may be utilized during early stages of NPD. The goal is, with the use of observation of potential consumers, to identify areas for opportunity that consumers are unable to express (Leonard and Rayport, 1997).

Christopher (1972) was early to point out that differentiated supply chain configurations can make a product appealing to multiple consumer segments. Market intelligence involves activities devoted to collect, analyze and report data related to a certain market situation (Stone et al., 2004), which makes it closely linked to not only the product, but also the supply chain configuration. The importance to look past the product is stressed by MacMillan and McGrath (1997) who suggests that a company should map the consumption chain, i.e. the consumers' whole experience of the product from the time the consumer discovers the product, until it is disposed of. This includes delivery services, storage services, and payment options. The consumers, however, may not perceive the product, and services the same way as the companies intend them. It is thus important to focus on perceived

consumer value, and not only the specified value (Parasuraman et al., 1985; Parasuraman et al., 1991).

The most notable taxonomies for supply chain configurations are based on efficient, or responsive supply chains. Lean supply chains focus on removing waste across the supply chain. This includes reduced inventory levels, lead-times, and supplier base, as well as lean manufacturing and just-in-time techniques (Christopher and Towill, 2001; De Treville et al., 2004; Naylor et al., 1999). The agile supply chain focus on the ability to respond to changes in demand. Agility is increased through reduced lead-times, as well as coordinated planning, improved communication, and sharing of demand information (Christopher and Towill, 2001; De Treville et al., 2004; Mason-Jones and Towill, 1999; Naylor et al., 1999). Lean and agile approaches may be combined to a leagile approach using the Pareto rule (Goldsby et al., 2006), separating base and surge demand (Goldsby et al., 2006), or postponement separating lean and agile approaches in a decoupling point (Alderson, 1950; Buckling, 1965).

Fisher (1997) proposes a taxonomy matching fashion products with agile supply chains, and commodities with lean supply chains. Mason-Jones et al. (2000) suggest that order qualifiers and winners should dictate what supply chain configuration to use. If cost is the order winner, a lean approach should be used, if service level is the order winner, an agile approach should be used. Christopher (2000) proposes that if demanded volume, variety, and variability is stable, a lean supply chain is preferred, and an agile is preferred if the parameters are unstable. Christopher et al. (2006) have a taxonomy based on similar parameters, but add lead-time. If the lead-time is short, and demand is predictable a lean approach based on continuous replenishment is suggested, if the demand is predictable and the lead-time is long, a lean approach based on planning and execution is suggested, if demand is unpredictable and the lead-time is short, an agile approach based on quick response is suggested, and if demand is unpredictable and lead-time is long, a leagile approach based on postponement is suggested. The underlying idea of all models is that agile approaches should be utilized when demand is unpredictable, and lean approaches when demand is predictable.

METHODOLOGY

This research is devoted to investigating how a demand led business model affects sourcing and inventory. The issue is examined through a literature review combined with findings from an embedded single-case study. The research is explorative, and the researchers have no control over the contemporary events that are examined, which is a suitable setting for case study research (Yin, 2009). Data collection was initiated in 2009 with 60-90 minutes interviews with key informants representing senior and middle management. The interviews have been followed by brief interviews and meetings with all employees. Qualitative data has also been collected from over 20 supply chain partners including manufacturers in China, serving team in China, and retailers in Sweden. Over 600 documents of primary and secondary, qualitative and quantitative, data have been used to provide a broad and rich picture of the studied phenomenon. 96 yearly reports from Alpha and nine of its competitors are used for economical analysis.

The research has been an iterative process with the case company where findings have been discussed, and revisited continuously. Established theories have been used to explain the findings, and to spark new research questions. Several data sources, and theories have been used to triangulate findings and build a chain of evidence. The methods employed have helped to increase validity, and reliability. The generalizability has been increased due to a strong connection to theory (Yin, 2009).

CASE STUDY FINDINGS

Alpha is a Swedish wholesale furniture company. Its main business activities are design and distribution of furniture. Furniture manufacturing is outsourced to manufacturers in China, and about 400 retailers (customers) are responsible for consumer sales. The retailers are independent from the wholesalers, and each retailer displays furniture from several wholesalers. Alpha had a business model that focused on minimizing costs and prices, but faced fierce competition and decided to change business model to focus on consumer insight. The company defines consumer insight as a profound understanding for implicit and explicit consumer needs. Consumer insight is gathered during NPD projects and utilized in early stages of NPD when agents from Alpha have been observing and photo-documenting potential consumers in their homes. As a result, the company has developed several furniture collections that provide added consumer value, or cater to a need that was previously unknown.

Since the new business model was adopted in 2004 until 2009, the number of stock keeping units (SKUs) increased with 150%. Between 2007 and 2009 sales figures have dropped for Alpha and its competitors with 39%. The total sales volumes for 2004 and 2009 were almost the same for the investigated companies, while Alpha increased their sales with 22%. During the same time period sales per SKU dropped over 50% for Alpha as a result of the decline in the market place, and the increased amount of SKUs.

The life cycle of products in the furniture industry may span from the time it takes to sell one container, to over 50 years. Due to long life cycles of successful furniture, it is perceived to be more important to have an accurate NPD process, than a fast one. The volume value of furniture is rather low, so companies need to consider filling rates in transportation. Sofas, for example, are often sourced from European manufacturers to reduce transportation cost. The case company's product range includes most furniture for the home, except for office furniture and sofas.

The sourcing side of the case company's supply chain is shown in Figure 1. Alpha monitors its supply chain back to the manufacturer. Manufacturers have the responsibility to source raw material and hardware. However, materials and hardware are chosen in collaboration with the manufacturers to ensure stability in sourcing and to enable monitoring prices. A serving team in China is employed to bridge geographical and cultural distances. The serving team has close collaboration with Alpha. Their main tasks are to perform quality controls in manufacturing, monitor manufacturing facilities, and manage operational tasks with the sending ports. Due to the importance of filling rates in container, the serving team may consolidate products from factories within close proximity.

Containers are shipped from five ports in China to the port of Gothenburg. About 96 % of the containers are then transported by truck to Alpha's distribution center (DC) the rest is shipped directly to retailers. Products that are shipped directly to retailers are key account customers, where Alpha provides knowledge about the Chinese manufacturing market. These products have low contribution margins, but also lower risk since Alpha does not need to consider forecast error. The products that are shipped to the DC are stored there until a consumer places an order in a store, and distribution from the DC is initiated. This research is focused on the products shipped to Alphas DC.

The new business model has resulted in an increase of SKUs, which in combination with decline in sales and the global economical situation has had big impacts on sourcing. The high increase in SKUs compared to sales has made the order quantities smaller. This has had two impacts on manufacturing. Firstly, the orders are too small to fill up a production line, for example painting. Secondly it is troublesome for many manufacturers since they deal with large order sizes from their other customers. The manufacturing environment is not suitable for small order sizes. Some manufacturers have started to produce larger quantities than the actual order quantity and take the risk of inventory in anticipation on future orders. Other manufacturers have down prioritized Alphas orders. In some cases the purchasing manager has been forced to place orders that are larger than preferred to secure manufacturing, and to hedge against future uncertainty in manufacturing. The average lead-time in manufacturing has increased with 50%.

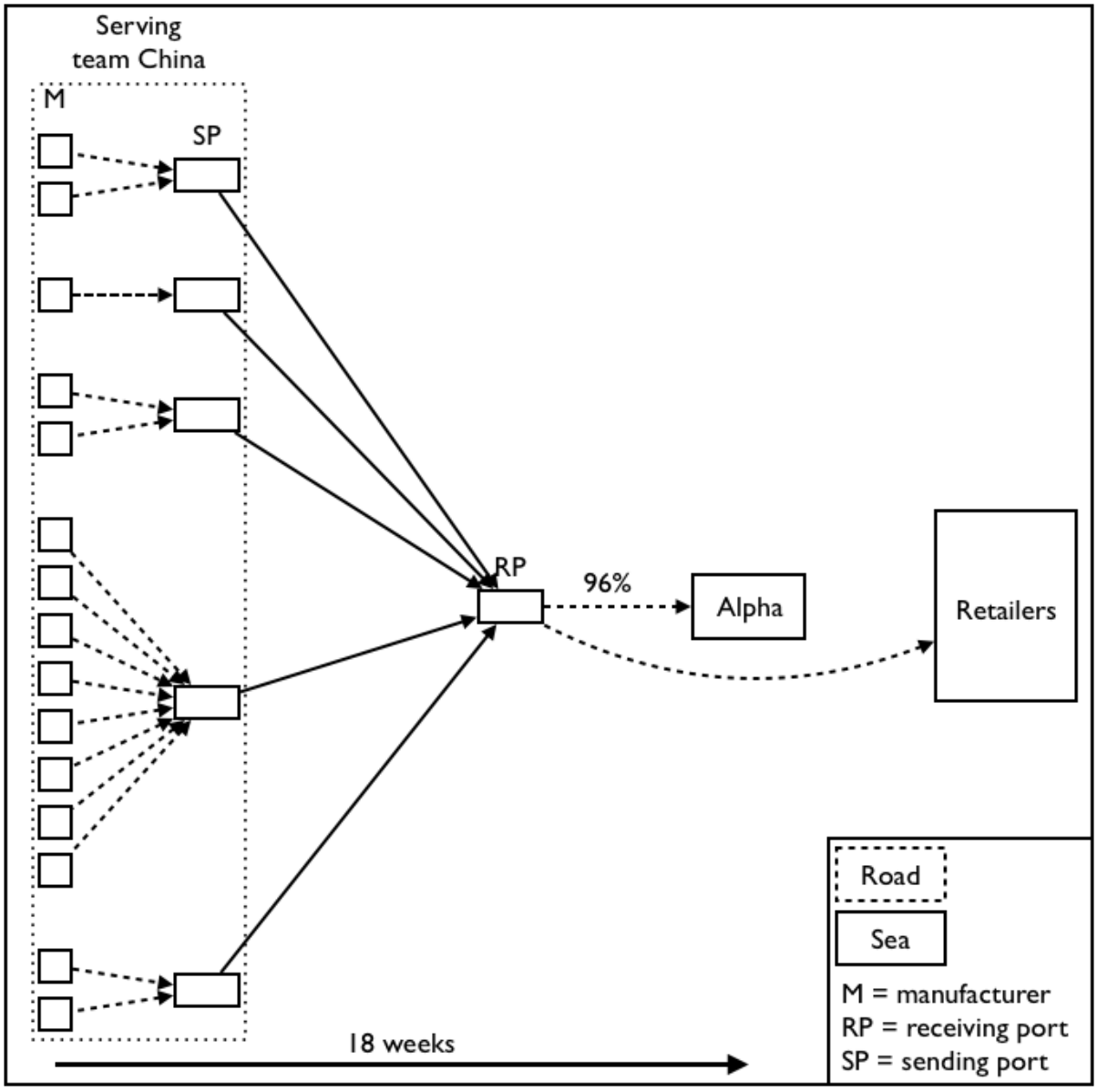

Figure 1: Alpha's sourcing system.

One issue with Chinese manufacturing is the quality of the furniture demanded by Swedish consumers. The Swedish market has a demand for furniture in a pristine white finish. In other countries, such as Norway, brown furniture has higher demand, and in the United States, there is big demand for furniture with a distressed look. Brown furniture is not as sensitive to a dirty manufacturing environment as white, and furniture with distressed look is treated with chemicals that produce a dirty finish. A dirty environment is not as expensive as a clean working environment, and since the Swedish market is small for Chinese manufacturers, the manufacturing plants are constructed with a dirty environment. Just before the end of 2010 the serving team called Alphas attention to two containers of furniture with dust grains in the lacquer, which were stopped before shipment.

The increased number of items and smaller order quantities have resulted in longer times to fill a container, and increased the need for consolidation. The result is not only longer lead-times, but has also increased the complexity with more SKUs per container. Furthermore, due to the global economical situation shippers have reduced the speed of their ships to

save fuel. The end result is that also shipping lead-times have increased with about 50%. The total lead-time has increased from about 12 weeks, to about 18 weeks.

The case company's inventory has increased with 67% between 2004 and 2009. During the same time period the inventory levels for Alpha and its competitors increased with 28% (Figure 2). Average turnover time in inventory for Alpha increased from 60 to 82 days, and from 52 to 65 days for Alpha and its competitors. The increased turnover time for Alpha is a result of the need to increase order sizes, and poor ability to adopt their business to the market decline.

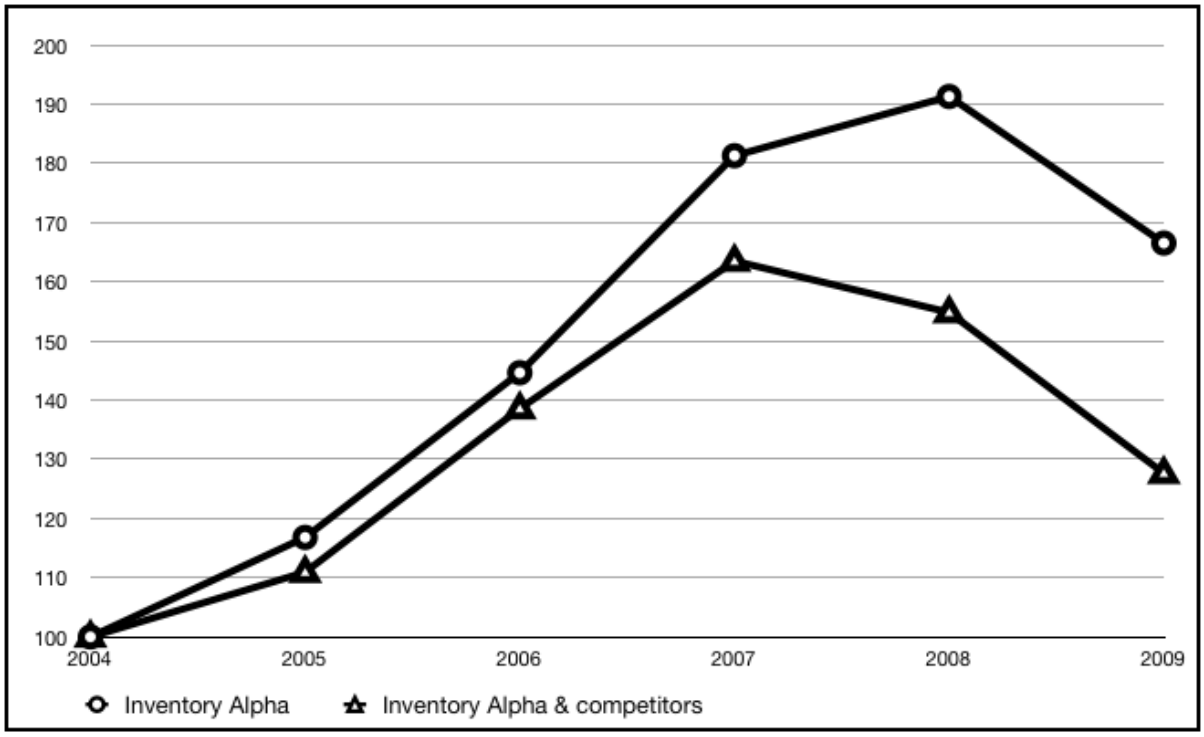

Figure 2: Inventory levels, 2004 indexed 100.

A one-year sales period starting in the summer of 2009 was compared with the inventory levels at the time (see Figure 3). To be able to compare the inventory with the sales 60% of the total article number had to be excluded due to discontinued products, and traceability in the data. Albeit a large piece of data is removed one finding is remarkable. 66% of the SKUs had one year or more of the demand in inventory, and the SKU with the longest inventory time would last over 52 years with current demand. In total there were 157 pieces of that particular SKU in stock and 3 were sold.

The case company has been focusing primarily on its demand chain processes, which has resulted in several new products offering added value. The technique for gathering consumer insight is very similar to the observation techniques of empathic design. However, the increase in article numbers, and the inability to adjust the business to changing market conditions have had detrimental effects on both sourcing and inventory. The sourcing strategy has a lean approach, but limitations and pressure from manufacturers have forced Alpha to place large orders.

The same sourcing strategy is utilized for all products, but the solution does not correspond well to the structure of the supply chain, nor the business model. In essence, there is bad fit between Alpha's DCM, SCM, and its ability to respond to changes in the market. Contrary to proposed models for supply chain configuration, fashionable products in the furniture do not have short product life cycles per se, and NPD does not need to be quick to respond to changes in demand.

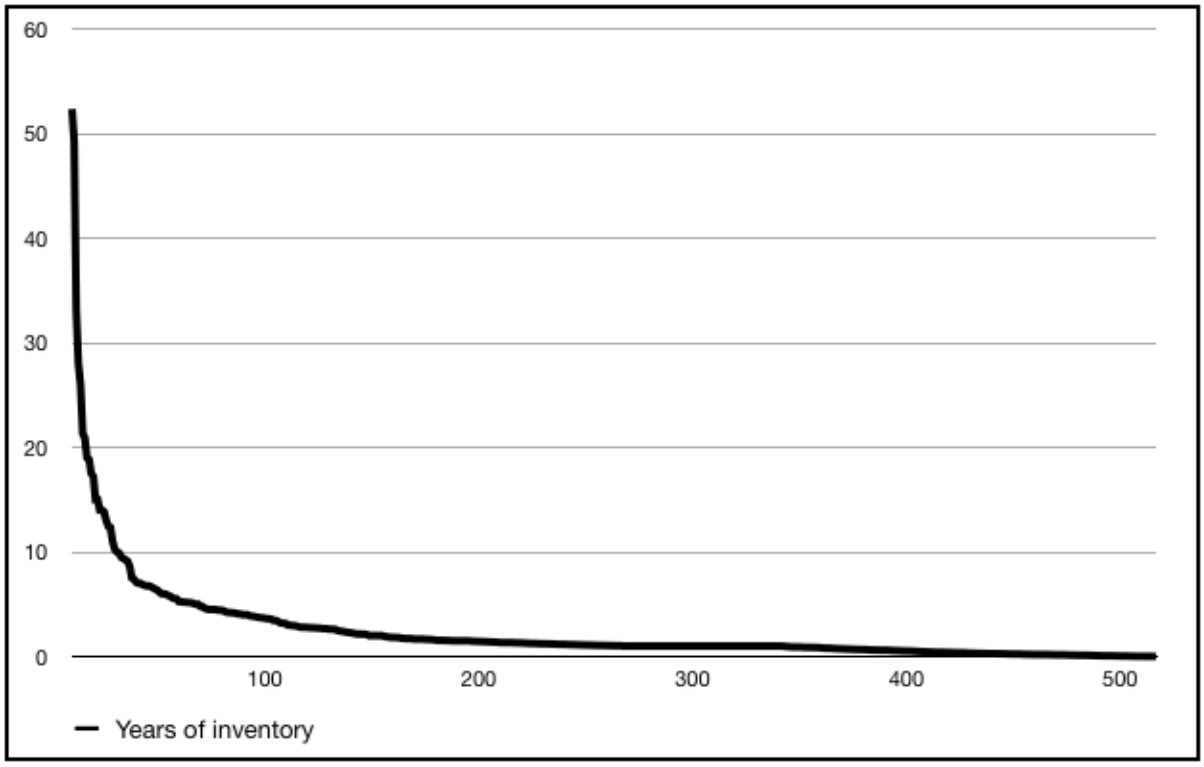

Figure 3: Years of inventory.

The connection between market intelligence, NPD, and sourcing is a good example of the close relation between DCM, and SCM. The case company has mainly focused on DCM processes, which has made the SCM processes inefficient. Moreover, the inability to respond to changes in the marketplace stresses the need to not only align processes internally, but in a way that enables them to change according to changes in the marketplace. The rigidity in Alpha's supply chain could be loosened up if leagile principles were adopted, such as using the Pareto rule to differentiate sourcing country based on predicted demand on the individual products.

CONCLUDING DISCUSSION

This research set out to investigate how sourcing and inventory are affected by a demand led business model. In this case the consumer oriented business approach has shown detrimental effects on both sourcing and inventory. Sourcing lead times has increased, sourcing complexity has increased, and the manufacturing country may not be suitable. Inventory levels has risen in comparison to sales, which has led to longer average turnover time in inventory. The case company is theoretically sampled, and it is not true to say that a consumer driven business model per default causes problems in SCM, but there is strong

support in theory that states that DCM, and SCM needs to be coordinated to create a competitive advantage. If DCM, and SCM were better managed on a macro level many of the problems may have been avoided. If, e.g. sourcing strategies were differentiated the higher cost of manufacturing might be acceptable due to increased responsiveness to changes in demand.

The main theoretical implication is that consumer driven business models needs to be coordinated according to DSCM theories, i.e. on macro level, to avoid sub-optimization of the management directions. The research also highlights that market orientation, or consumer insight as in this specific case, alone in not a path to success. The main practical implication is that managers need to devote time to align DCM, and SCM. Managers that want to pursue a premium market should not only focus on the elegance of their products, but also need to device a SCM strategy that is coordinated with the DCM strategy. The main social implication is that differentiated sourcing may move employments from low cost countries closer to the consumer market. The problems with manufacturing sofas in China is a good example of how supply chain strategy may have a social impact, as manufacturing has been moved to Europe.

Globalization and the quest for lower prices have caused manufacturing companies to outsource production activities to low cost countries. The move to global sourcing, however, may come at a cost that is larger than the cost savings in manufacturing. The case company suffers from several issues due to their sourcing strategy. The manufacturing industry in China is not suitable for the quality demands, nor the requested volumes. The result is poor efficiency in sourcing, and inventory. Alpha's consumer driven business model has increased the number of products, and the more the model is implemented the more it is likely to cause harm to the efficiency in the supply chain. Companies that device a business strategy similar to the one of the case company may need to reconsider the relentless quest for decreased manufacturing cost, and instead consider the total cost. Sourcing from countries closer to the consumption market may increase manufacturing cost, but if the supply chain strategy is differentiated based on the Pareto rule only products with low turnover will be affected.

It has only passed 6 years since Alpha changed their business direction. It is still not possible to say if the shift in business direction was a vise choice, and that the issues caused to SCM might just be an investment cost for the new business direction. However, if the change in business direction was undertaken with stronger theoretical support, it is likely that the investment cost would have been lower. This research has only investigated one company. Even though findings are in line with theory, more research is needed to truly understand how consumer driven business models affects SCM processes. Moreover, to fully understand the case company's situation would require that studies continue for several years.

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DEVELOPMENT OF A DYNAMIC STRATEGIC PURCHASING MANAGEMENT MODEL FOR A PROJECT ORIENTED GLOBAL HIGH TECH COMPANY

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ABSTRACT

Goal of the research was to design a Dynamic Strategic Purchasing Model that meets the requirements of a global company operating in the global project environment.

The Case Company's Delivery Process (including designing, purchasing of materials and equipment, manufacturing, delivery, erection and start-up) is organized as customer specific Delivery Projects, which are complicated 1-2 years investment projects implemented by dozens of suppliers and subcontractors.

Case Company is able to manufacture and supply a complete Mill but as a Case Product in this research has been selected one essential part of it.

Though the basic construction of the Case Product is standardized, the real construction of the Product is different in every Delivery Project because of process requirements, customer requirements and local requirements of the Country where the Product will be delivered. The Project Country, the final destination of the Product, has a big impact to purchasing of the parts and subcontracting. Locality of the suppliers, location near the Project Site, where the Product will be delivered, is seen as a real advantage based on the empirical research.

On technological point of view, the most important suppliers for the Case Product are those who make the high pressure parts or otherwise technically complicated parts.

Supplier evaluation and selection is required to ensure that only reliable, competitive suppliers, which are able to supply products and services on needed quality level, are used.
A new supplier evaluation model was developed and has been used in the Case Company since that.

Main outcome of this research, a Dynamic Model for Strategic Purchasing Management, is based on two known, Kraljic's and Bensaou's, portfolio models but the combination and application principals are new, as well as the Supplier Evaluation and Selection principals included in the Model.

Keywords: Strategic Purchasing Management, Supply Chain Management,

INTRODUCTION

Supply Chain Management is one of the key interests in strategic planning and it has been one of the main objects for strategic changes in the Case Company. Purchasing as one of the most significant parts of Supply Chain Management in the Case Company has been selected as the research context of this study. In the Case Company cost of purchased materials, parts and subcontracting is 70-80% of the project costs.

There are common strategies, procedures and principles presented of Supply Chain Management and Purchasing Management in the studied literature. A lot of discussion for example of the portfolio models could be found, as well as criticism of their two-dimensional thinking and simplifying buyer-supplier relationships [4]. Network models have been popular during last years. One of the network models presented in last decade is the agile supply chain model. It stresses collaborative relationships as the supply chain strategy [14]. The presented models are more or less oriented in continuous, constant purchases and are not interested in changing, dynamic project environment.

The Case Company's Delivery Process (including designing, purchasing of materials and equipment, manufacturing, delivery, erection and start-up) is organized as customer specific Delivery Projects, which are complicated 1-2 years investment projects implemented by dozens of suppliers and subcontractors. Delivery Process as an element of the Business Processes of the Case Company is presented in Figure 1.

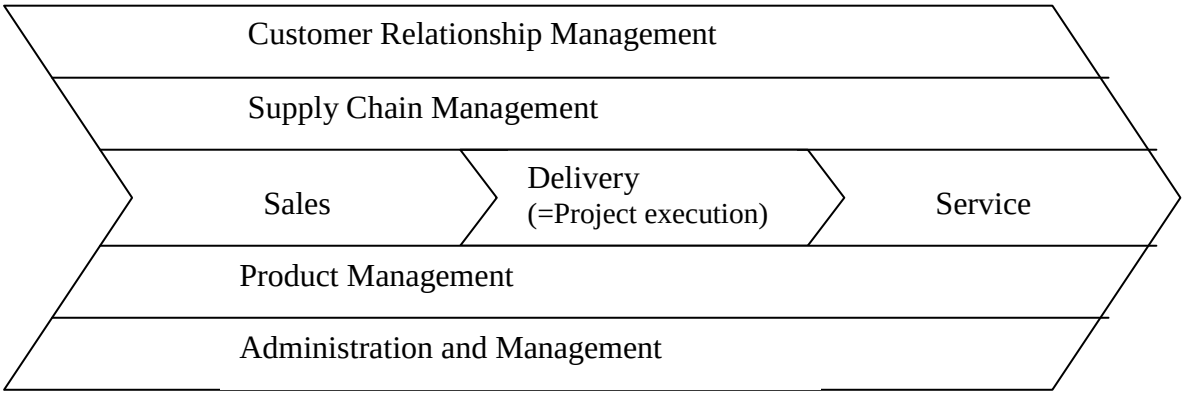

Figure 1: Case Company's Business Processes.

Industry, on which the Case Company operates, is growing fast in South-America, Asia and Russia. Those areas will be also destination areas for the Delivery Projects of the Case Company.

New market areas have generated in the Case Company need to manage global supplier network. Importance of global purchasing has increased and strategic purchasing planning is of great concern.

In this study it was tried to answer to question:

- What kind of purchasing management shall be used for strategic purchasing in dynamic global project environment?

Goal of the research was to design a Dynamic Strategic Purchasing Model that meets the requirements of a global company operating in the global project environment. Empirical background and logic of the development process is described in figure 2, which also is follows the reasoning in this paper.

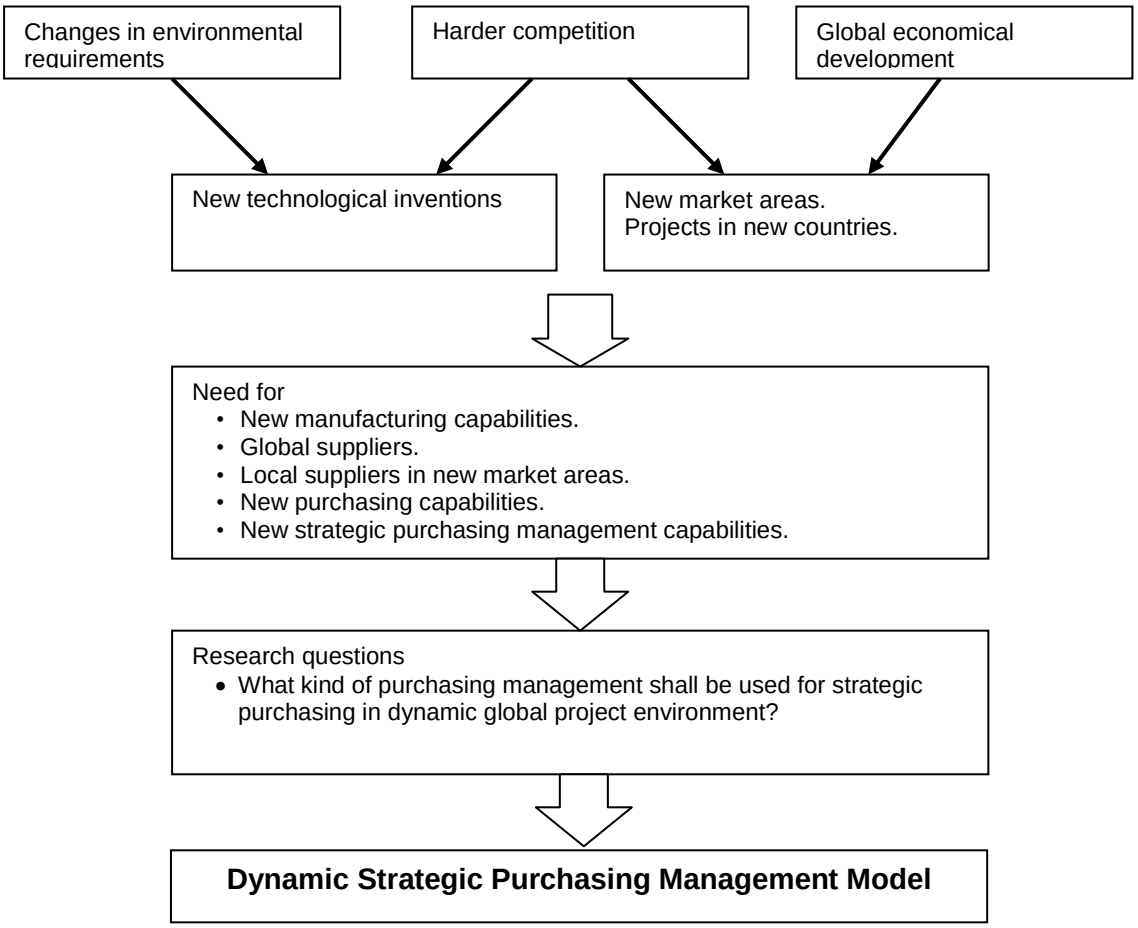

Figure 2: Development of a Dynamic Strategic Purchasing Management Model.

RESEARCH PROCESS

The empirical research for this study was conducted during five years as a Project Purchasing Manager in the Case Company.

The Case Company is able to manufacture and supply a complete Mill but as a Case Product in this research has been selected one essential part of the Mill.

Though the basic construction of the Case Product is standardized, the real construction of the Product is different in every Delivery Project because of process requirements, customer requirements and local requirements of the Country where the Product will be delivered. The final destination of the Product has a big impact to purchasing of the parts and subcontracting needed.

On technological point of view, the most important suppliers for the Case Product are those who make the most complicated high pressure parts or otherwise technically complicated parts.

Supplier evaluation and selection is required to ensure that only reliable, competitive suppliers and subcontractors, which are able to supply products and services on needed quality level, are used.

It was noticed in the Case Company in 2005 that strategic purchasing procedures and tools shall be evaluated to be sure of their suitability for the expanded and changed business environment and this research was started for that purpose.

This research was conducted during five years for the Case Company, a Mill manufacturer. Conducting the Research is presented in Figure 3.

2005-2007	Analysis of the status of Supply Chain Management, Purchasing planning and operations in the Case Company by reviewing - Strategic Purchasing Management - Purchasing Planning - Supplier Evaluation and Selection Process Business Process Handbook and other instructions and by doing Interviews
2005-2008	Review of available tools and methods by - literature studies - participating lectures and seminars
2005-2010	Developing the Strategic Purchasing Management Model by - improving the Supplier Evaluation and Selection Process - defining the main features of the Model based on analysis of the current status of Purchasing planning and operations - testing the Model in a Delivery Project - finalizing the Model based on the results got during the test and future view and plans of the Case Organization

Figure 3: Conducting the Research.

Goal of the research was to find or design a Dynamic Strategic Purchasing Management Model that meets the requirements of a global company operating in the global project environment.

Qualitative and quantitative research: review of organizations procedures, instructions, management books and data, and interviews were done to be aware of the purchasing strategy, and plans and tools used and their suitability to the Case Company.

LEARNING BY DOING- DEVELOPING AND TESTING THE STRATEGIC PURCHASING MANAGEMENT MODEL IN A CASE PROJECT

Qualitative and quantitative research

- Review of procedures, instructions, management books and data
- Interviews: 8 purchasing and project responsible interviewees (total number of personnel in those operations was 23).

was made to be aware of the purchasing strategy, and plans and tools used in the Case Company, and suitability of those based on experience of the interviewees.

Main findings of the review of the organizations procedures, instructions and management books were:

- Some critical subjects from the Case Product's point of view were not evaluated when selecting suppliers and subcontractors.
- The supplier evaluation process and procedures did not cover needs of global purchasing environment of the Case Company.
- The auditors had lack of product knowledge and process knowledge for auditing Case Product's pressure part manufacturers.
- There was a company level purchasing strategy, and upper level instructions and principals defined for category purchases. (Company level categories were material groups of the A-level materials selected with ABC-analysis).
- The Supply Chain Management main principles were good and useful as well as linking of Supply Chain Management strategic focus to the Company business planning.
- Because purchasing volume of the main parts of the Case Product was not big enough (not on A-level) on whole Company point of view, the main parts of the Product were not included in the categories, and there were no strategic purchasing planning principals, procedures or instructions for purchasing of these parts => purchasing planning and purchasing was done more or less uncontrolled and in a different way in every Delivery Project.

Main findings of the interviews were:

- Important characteristics of the suppliers and subcontractors besides competitive pricing, on time deliveries and good product quality were
  - up-to-date knowledge
  - perseverance and trust
  - teamwork capability
  - good chemistry

- Interviewees pointed out the following questions:
  - How to evaluate new suppliers in new project countries far away with different kind of knowledge, procedures, culture etc.?
  - Will there be longer partnerships in the future? Or will there be only one time relationships with local suppliers in those countries where products are delivered to in the future?

It was obvious that Supplier Evaluation and Selection Process have to be improved to meet requirements of the new project and purchasing environment with new requirements.

Starting point for improving of the Supplier Evaluation and Selection Process was to renew the Supplier Evaluation form. Earlier developed but very seldom used Audit List and Supplier's Annual Performance Form were used as basis. The form and content of the Audit List was modified by adding new check points and questions, and by designing a form to be suitable for global use among suppliers operating in different countries and cultures.

The new Evaluation Form was tested by sending it to 20 suppliers. The suppliers which were selected as the objects of the test had not been evaluated earlier because those suppliers were used only for needs of the Case Product and on the point of view of the whole Company were too small (based on ABC analysis and 20/80 rule) to be evaluated.

The test was started by sending the Evaluation Form to suppliers by e-mail.

Suppliers were asked to fill in the Form and send it back to the purchaser who had sent the Form. After sending the Evaluation Form, purchasers called the suppliers and fixed up the return date for the Form and meeting date with the supplier.

Suppliers filled in the form and returned it back to the purchaser by e-mail.

Purchasers met the suppliers and reviewed the information given in the Form and compared it with supplier company's operations and analyzed reliability of supplier company's self assessment results presented by them in the returned Form.

It was also found important that evaluated suppliers shall be scored with clearly defined criteria. Result of the evaluation shall not be based only on opinions of the evaluator. For each factor and aspect important to the Case Company, there must be a quantitative, like on time delivery %, or qualitative criteria like willingness and ability to improve operations.

When making the final decision of the scoring and selection of the Supplier, also performance in earlier projects shall be taken in consideration very strongly, if that information is available.

Main interest in the purchasing operations of the Case Company point of view of the Case Product was before 2007 more on operational level than on strategic level. To be competitive on global markets real strategic thinking must be applied also in purchasing of the parts of the Case Product.

Research for Strategic Purchasing Management Model was started. As main characteristics for the Model to be developed were defined: The Model shall be able to be used in every Delivery Project with its own special features coming from performance and process technical requirements by the customer, the local laws and requirements, political climate, nature and climate etc of the project country, from the scope of the delivery, and from the financial targets of the Case Company itself.

The model shall answer to questions:

- What could be bought from one-time or some-time local suppliers and what must be bought from already known long- term partners (location independently)?
- How to select "right" suppliers?
- How to manage supplier relationships?

It was decided to test and find a method to categorize the parts of the Case Product to be able to prioritize purchasing planning and operational purchasing as well as supplier relationships. Parts of the Product were classified into four categories by using Kraljic's portfolio model [18].

According to Kraljic, a company should sort out all its purchased items into four categories: strategic products, bottleneck products, leverage products and non-critical (routine) products in terms of profit impact and supply risk. Analysis of profit impact of a given supply in terms of volume purchased, total purchase cost, impact on product quality and business growth shall be executed, as well as assessment of supply risk in terms of availability, number of suppliers, competitive demand, storage risks, substitution possibilities and make-or-buy opportunities [18].
Strategic items are those with high profit impact and high supply risk. Bottleneck items have low profit impact but high supply risk. Leverage items have high profit impact but supply risk is low. Non-critical items have low profit impact and low supply risk [18].

In the Case Product among strategic parts are e.g. high pressure parts, high pressure piping, steam drum and some other. Among strategic items are also "CORE" parts, which the Company wants to manufacture itself.

Simultaneously with the development of the Strategic Purchasing Management Model, the Model was tested step by step in a Case Project to Russia.

It was noticed during the Case Project execution, that Kraljic´s classification could be used as a basis in this global project environment but local aspects of the country and its culture and requirements of local norms and authorities had to be taken into account as well as the content and scope of the project.

As supply risks, besides those ones that Kraljic has introduced, were identified:

- local laws and requirements the parts are required to fulfil
- requirements for the parts coming from political environment (e.g. domestic content requirement versus know how of the suppliers in the project country)
- requirements for the parts coming from nature and climate of the project country (e.g. seismic requirements, freezing etc)

Logistics costs of the parts to or in the project country could have a big profit impact depending on the same factors that were recognized as supply risks. Local laws and requirements concerning transportation of parts with certain size or weight could require extra arrangements and cause extra costs, etc. Availability and condition of the roads and railway, weather conditions, differences in altitude etc are also important profit impact

factors to be taken into account when classifying parts of the Case Product for a certain project.
Classification model of the parts of the Case Product is presented in figure 4.

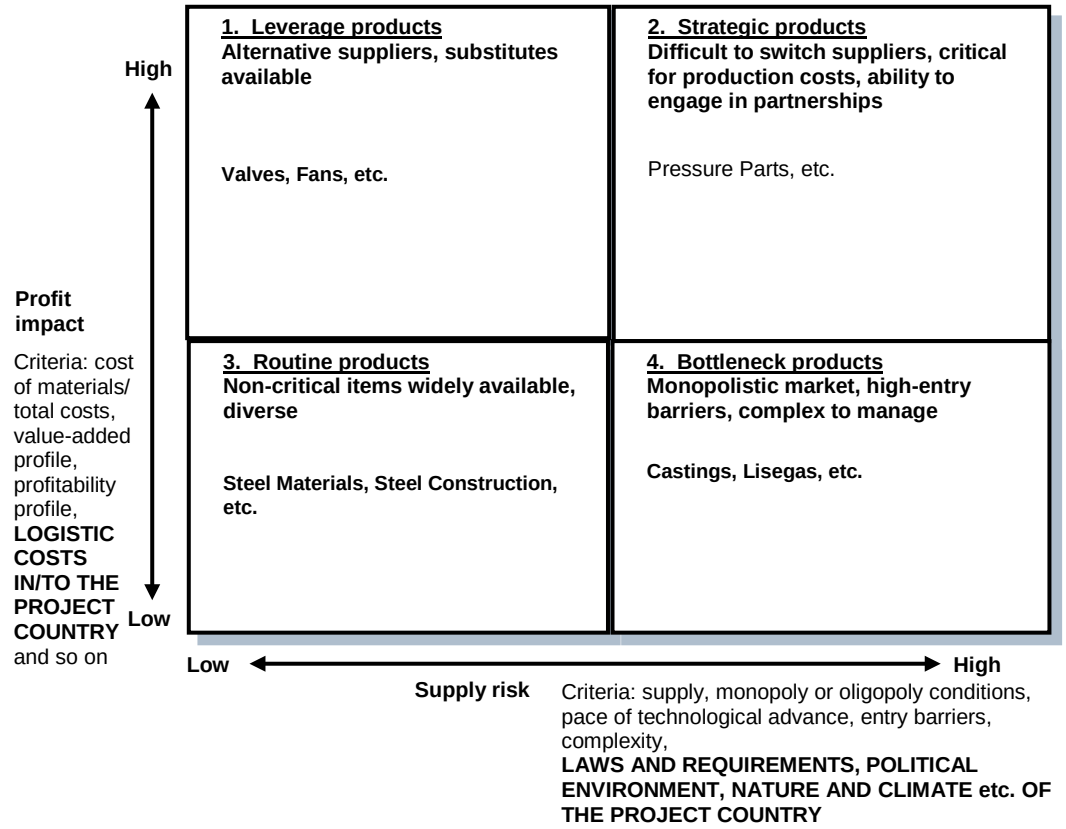

Figure 4: Classification model of the Case Product's parts. [18]

Kraljic´s Planning the Supply Management Strategy model with all steps:

- classification
- market analysis
- positioning
- action plans

was decided to take as a guideline for the development of the Strategic Purchasing Management Model for the Case Company.

To ensure also the flexibility and good chemistry (required by Case Company's interviewees), it was thought that there should be also in the future longer supplier relationships at least for delivery of strategic and bottleneck parts besides shorter local supplier relationships for other parts.

A model for supplier relationship management was also needed for the Case Company.

Professor Bensaou emphasizes companies to manage a portfolio of relationships instead of managing with only one design for all relationships. He offers a two-step framework; first identify which type of relationships matches the competitive conditions surrounding the product or services exchanged. And second, design the appropriate management model for

each type of relationship. If the design of each relationship matches to its external context, under-designed and over-designed relationships could be avoided [1]. Bensaou´s portfolio model is presented in figure 5.

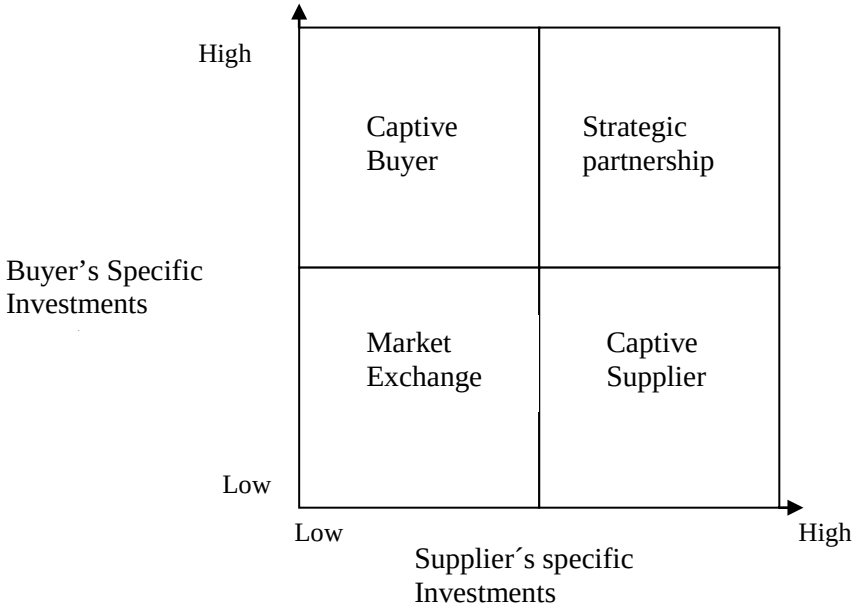

Figure 5: Bensaou's portfolio model. [1]

The Market Exchange cell represents a relationship in which neither party has developed specialized assets for cooperation and they can work together using general-purpose assets. Each party can turn to the marketplace and shift to another business partner at low cost and minimal damage [1].

Captive Supplier cell represents a relationship where supplier unilaterally makes investments to win the competition and keep the business with the customer [1].

Captive Buyer cell represents a relationship where buyer is held hostage by a supplier free to switch to another customer [1].

In Strategic Partnership cell both parties have posted high assets, both tangible and intangible investments, into the relationship [1].

The four cells differ along three sets of contextual factors: 1) the characteristics of the product exchanged and its underlying technology, 2) the level of competition in upstream market, and 3) the capabilities of the suppliers in the marketplace [1].

Bensaou found that management variables that make the relationship high or low performing were: 1) information sharing practices, 2) characteristics of boundary spanners' jobs, and 3) the social climate within the relationship [1].

Designing of relationships consists of three steps [1]:

1. the strategic selection of relational types to match the external conditions given by the product, the technology, and the market
2. the identification of an appropriate management profile for each type of relational design
3. matching design of relationship to the desired management model

It was decided use and test main principles of Bensaou's portfolio model to manage the Supplier Relationships in the Case Project.

To keep suppliers knowledge up-to-date, and to reach perseverance and trust and to have good teamwork and good chemistry during project execution as the interviewees required, supplier relationship management shall have similar characteristics as Bensaou has defined for the strategic partnership in his portfolio.

According to Bensaou, there are two kind of successful relationships: high requirements-high capabilities and low requirements-low capabilities. There are also two paths to failure, under-designed relationship and over-designed relationship [1].

Bensaou emphasizes companies to manage a portfolio of relationships instead of managing with only one design for all relationships. He offers a two-step framework; first identify which type of relationships matches the competitive conditions surrounding the product or services exchanged, and second, design the appropriate management model for each type of relationship. If the design of each relationship matches to its external context, under-designed and over-designed relationships could be avoided [1].

As a conclusion to reach the best possible relationship with every supplier, the supplier relationships shall at first analyzed and classified in every Delivery Project of the Case Company and after that the appropriate management model for each type of relationship shall be designed.

CONTRIBUTION

Supplier Evaluation and Selection Process of the Case Company was improved to meet requirements of the new project and purchasing environment.

Starting point for improving of the Supplier Evaluation and Selection Process was to renew the Supplier Evaluation Form.Main content/ main titles of the new developed form were as follows:

- General Supplier Information.
- Available delivery possibilities.
- Description of typical products or services.
- Volume per year, biggest customers etc.
- Capacity.
- Computer Systems.
- Quality System.
- Welding Qualifications.
- Available NDT-Methods.

- Other Testing Equipment .
- Fabrication.
- Welding.
- Machining.
- Heat Treatment.
- Surface Treatment.
- Transportation.
- Business Operations.
- Sales in euro.
- Sales price development +/- % during last 5 years.
- Cost development +/-% during last 5 years.
- Quality measures, e.g. % of faults found during manufacturing.
- Delivery reliability.
- Development Projects (Key projects (2-3 pc) during last and coming 5 years).
- General evaluation of the company with SWOT analysis (strengths, weaknesses, opportunities and threats) (Supplier's own opinion).
- Cooperation with Customers.
- Other comments and feedback.

The following Supplier Scoring and Selection criteria were also developed:

Good:

- Performance in earlier projects good, on time delivery % at least 9 %, price increase 0 % (or at least less than 2 % if material price increases) per year, faults during manufacturing less than 3 %, capacity big enough = at least three times the Case Company's needs, suitable IT infrastructure = MS Office, Adobe Acrobat, CAD, SAP or similar, Quality System in use for at least 3 years, financial situation good, regular customer need based development and improvement projects in progress, able to fulfill service needs of the Case Company.

Sufficient

- Performance in earlier projects acceptable, on time delivery % at least 95 %, price increase less than 3 % per year, faults during manufacturing less than 3-5 %, capacity big enough = at least two times Case Company's needs, suitable IT infrastructure= MS Office, Adobe Acrobat, CAD, SAP or similar, Quality System in use 0-3 years, financial situation good, able to fulfill service needs of the Case Company.

Rejected

- Performance in earlier projects bad or on time delivery % less than 95 % or price increase more than 6 % per year or faults during manufacturing more than 5 % or capacity not big enough = at least two times Case Company's needs or no Quality System in plans or financial situation not acceptable or not able to fulfill service needs of the Case Company.

The usage test of the new Form and Supplier Evaluation and Selection procedures was completed in two months by five purchasers.

The Form and Scoring and Selection Criteria were found suitable for needs of the Case Company and they were decided to take in continuous use and have been used since that.

Main outcome of this research is a Dynamic Model for Strategic Purchasing Management. Developed model is based on two known, Kraljic´s and Bensaous, portfolio models but the combination and application principals are new as well as the Supplier Evaluation principals included in the Model.

The developed Dynamic Strategic Purchasing Management Model is presented in figure 6.

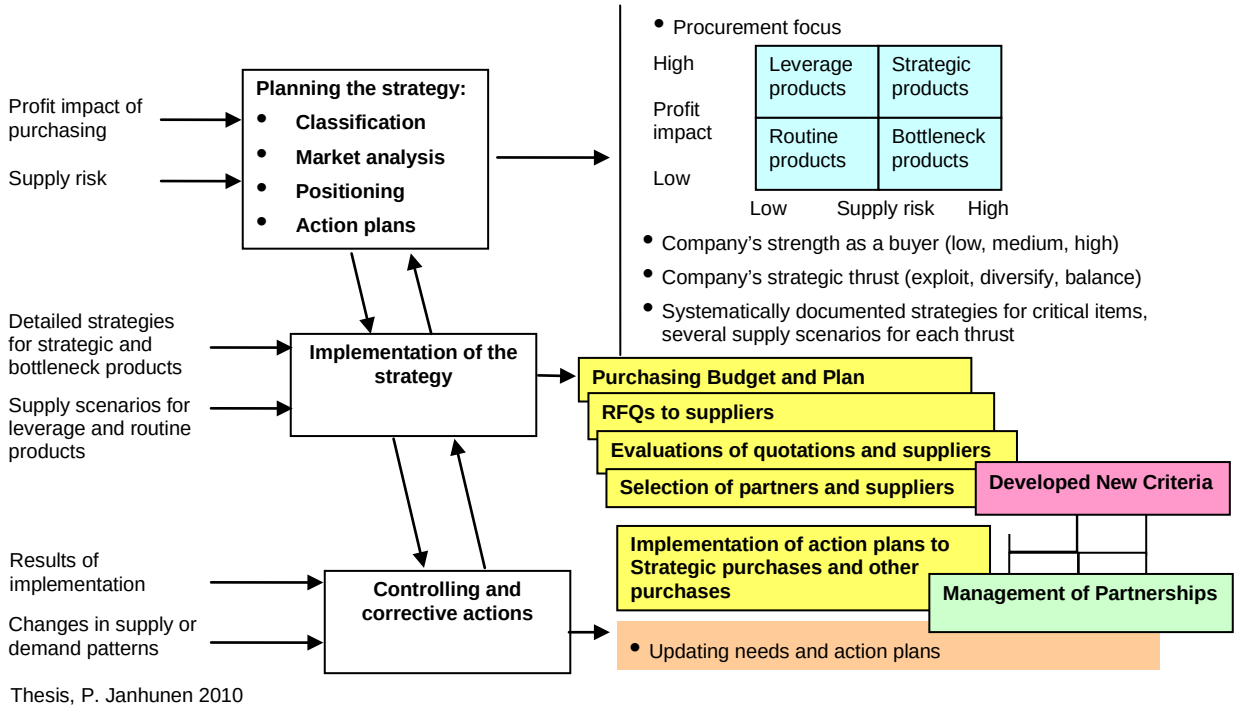

Figure 6: Dynamic Strategic Purchasing Management Model.

The usage of the Model in every project and updating of it after every usage makes the model dynamic and all the time up to date. The developed Model and usage of it are significant improvements on business and academic point of view and lead to better performance in a Project Oriented Global High Tech Company as testing in the Case Company proves.

Based on the Research and test of the Model during Case Project following thesis should be followed:

1. Material classification by using modified Kraljic's portfolio model has to be done for every project on the sales phase (or at the latest in the beginning of the project). Local aspects of the project country and its culture and requirements of local norms and authorities have to be taken into account when assessing profit impact and supply risk.
2. Purchasing market analysis of the project country has to be done to find best potential suppliers.

3. Strategic positioning (exploit, balance, diversify) of materials in each category has to be done.
4. Several strategic supply scenarios, action plans, have to be developed for each item category. And for the critical (strategic and bottleneck) purchasing materials, the outcome has to be a set of systematically documented strategies for them.
5. Suppliers have to be evaluated and the best possible ones selected according to the Classification model and developed Supplier Evaluation and Selection Process.
6. Detailed strategies for strategic and bottleneck products and supply scenarios for leverage and routine products have to be implemented.
7. Managing of the supplier relationships must be a key interest. To manage Supplier Relationships successfully modified Bensaou's portfolio model shall be used as guidance.

DISCUSSION

Developed model is a combination of two old, Kraljic´s and Bensaous portfolio models but new features added to the models, makes the developed model new.

Innovation was tested in a real delivery project. Criteria were project's financial results.

The developed model and method are significant improvements and use of them leads to better performance in a project oriented global high tech company as the test in a real project proves. Results (availability/delivery time of the materials, material costs, quality of materials and services) and financial results of the Case Project are better than in average.

The Case Project has been completed. Mill is in operation and acceptance of the Project Delivery has been got by the customer and authorities in 2010.
Presented proposal to use the Model in every project (for every different project country and for every different customer) and update it after every usage, makes the model dynamic and all the time up to date.

Results got, also other than financial ones, by using the Model in new delivery projects, must be collected and analyzed to be able to improve the Model.

This research proves that old models and methods could be used successfully also in different kind of business environment than they actually have been developed.

To ensure usage of the developed Model, next research step should be to define, what kind of tools are needed to make the usage easy and quick.

Another important Research Question could be: what kind of supplier relationships there will be in the future in the possible new purchasing market areas? Will there be suppliers or supplier networks? How the supplier relationships shall be managed?

It could be also interesting to research in the Case Company, how to combine purchasing categories and developed model to get the advances of the combined purchasing volumes

and at the same time take into account the special requirements of the dynamic global project environment.

CONCLUSION

This research was conducted during five years in Mill manufacturer's organization.

Goal of the research was to design a Dynamic Strategic Purchasing Management Model that meets the requirements of a global company operating in the global project environment.

Qualitative and quantitative research: review of organizations procedures, instructions, management books and data, and interviews were done to be aware of the purchasing strategy, and plans and tools used in the Case Company and suitability of those based on experience of the interviewees.

Main outcome of this research is a Dynamic Model for Strategic Purchasing Management. Developed model s based on two known, Kraljic's and Bensaou's, portfolio models but the combination and application principals are new as well as the Supplier Evaluation and Selection principals included in the Model.

Strategic Purchasing Planning shall be done for each project on the sales phase or at the latest in the beginning of the project.

Usage of the Model in every project and updating of it after every usage makes the model dynamic and all the time up to date. The developed Model and usage of it are significant improvements and lead to better performance in a Project Oriented Global High Tech Company as testing in the Case Company proves.

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FACILITATING INTERNATIONALISATION THROUGH TRADE FAIRS: CASE CHINA

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ABSTRACT

Business growth is usually strongly sought issue for SMEs. Since the size of domestic market in Finland is relatively small, internationalisation is an issue worth to consider for many SMEs. Internationalisation as a research topic is studied widely, and on several approaches. A route to internationalisation is determined by factors that are emphasized differently depending on the approach. The purpose of the study is to find out how trade fairs affect the factors in practice and how scarce resources should be allocated to gain an efficient trade fair outcome.

Research is conducted as a case study with four Finnish SMEs. The companies joined a delegation that participated in a trade fair held in Chengdu, China. The empirical data is collected by documentation, in-depth interviews, and by direct observation and participant-observation. The literature review aims to discover how trade fairs advance SME internationalisation. The first research question analyses the results gained from the fair activities. Finally, the second research question seeks solutions to improve the whole participation process.

The major factors advancing internationalisation are listed in the literature review. The most common theme among trade fairs, SME internationalisation and China is associated with networking. The empirical data indicates that the fair yielded plenty of significant information needed in internationalisation. However, the analysis of different participation phases revealed that trade fair outcome could have been remarkably improved with certain target actions such as creating clear guidelines for follow-up and finishing the façade of participating companies.

Keywords: SME internationalisation, trade fairs, China, networking

INTRODUCTION

Business growth, leading for example to increased profit or economies of scale, is usually strongly sought issue for start-up companies and SMEs (Small and Medium sized Enterprises). Since the size of the domestic market in Finland is relatively small, internationalisation is a topic worth to consider for many Finnish SMEs. The target market has huge impact for the internationalisation process since the business environment can clearly differentiate from a country to another (Johanson & Vahlne 1990). Current economical growth occurs especially in China that has been pulling the whole global economy during the recession. Growth combined e.g. with large domestic market and infinite labour force makes China conspicuous destination for companies to expand their business.

Johanson and Vahlne (1990) refer to the psychical distance, when considering differences in business environment. It can eventually emerge as a lack of understanding of laws, language, business practices, etc. (Oviatt & McDougall 1994). Consequently, before the actual business can start in a new market area, companies should gain knowledge of the business environment. When completing the groundwork properly, barrier to enter the foreign market gets significantly lower. (Johanson & Mattsson 1988.) A potential way to reach all of these preconditions and make groundwork is participating in trade fairs. They could also offer significant information for SMEs of preferred policies and actions when operating in the international business field. What really separates trade fairs out of other ways of marketing is that they enable inexpensive face-to-face contacts and fluent information exchange between different trade fair participants (Bellizzi & Lipps 1984, Kerin & Cron 1987).

This paper studies how SMEs could utilise trade fairs to advance their internationalisation process. The study investigates four case companies and their participation in a trade fair held in Chengdu, China. The study focuses especially on the companies' actions during the trade fair and the results generated by the fair. The whole participation process was arranged by the Department of Industrial Engineering and Management (DIEM) in the University of Oulu. Research questions are defined below.

RQ1: What kind of results was gained from the fair activities?
RQ2: How the participation could have been improved?

The first research question is based on interviews with the case company representatives and on the researchers' observations during the fair. The actions are compared with the companies' purposes to participate in the trade fair. Only short-term results can be studied, but the results are discussed whether they can yield any long-lasting effects on companies' international business operations. The second question is a comparison of the theoretical analysis and the empirical part based on the researchers' views how the participation could have been more effective and yield more significant results.

The paper starts with presenting theoretical background, which consists of three different themes: internationalisation, trade fairs and Chinese business environment. The next chapter introduces the empirical cases and the participation phases in general. After the

empirical part the discussion chapter answers the research questions and especially reflects the results of the case study to the theoretical background simultaneously attempting to find improvement actions for the case companies.

THEORETICAL BACKGROUND

The approaches of internationalisation

Literature distinguishes three main internationalisation approaches for SMEs. The oldest model, the stage approach, sees internationalisation process proceeding step by step. Foreign market entry is expected to start from markets that have the shortest psychical distance for the company. International appearance can thus be seen expanding like rings in the water. The mechanism for internationalisation is a dynamic process in which market commitment of the company and the experiential knowledge of the managers define the commitment decisions and current activities of the company. As every loop of the process increases learning in the company, so is the internationalisation enhanced as well. (Johanson & Vahlne, 1977.)

The network approach suggests that business relationships facilitate internationalisation hence enabling market entry also to psychically distant countries. Relationships are valuable intangible assets for companies, and they affect the companies' marketing strategies and how industrial markets function. Success of internationalisation is dependable on a company's positions in the networks, its ability to coordinate internal resources and ability to exploit its relationships to have access on external resources. Four different situations are separated based on the degree of internationalisation of the market and on the degree of internationalisation of the company: the early starter, the late starter, the lonely international and the international among others. (Johanson & Mattsson, 1988.)

International new venture or born-global approach is developed on the notion that more and more companies have gone through a rapid internationalisation process (Oviatt & McDougall, 1994). Technological developments especially in transportation and communication have increased globalisation, which, in turn, has affected the number of people involved in international business (Oviatt & McDougall, 1994; Madsen & Servais, 1997). A precondition for rapid internationalisation is an experienced manager that has desire and vision for rapid international market penetration (Johnson, 2004). Other necessary elements for sustainable international new ventures are alternatives for limited resources, i.e. having access to external resources, and finding foreign location advantages when combining domestic mobile resources with foreign less mobile resources. Unique knowledge of the mobile resources has the greatest influence on rapid internationalisation. Finally, unique resources are needed to protect and renew knowledge, which maintains the competitive edge and keeps the company sustainable. However, this is one of the major difficulties for SMEs, since they are usually lacking of resources. (Oviatt & McDougall, 1994.)

The role of and practicalities in trade fairs

Trade fairs are the second theme of the theoretical part. Exhibitors use trade fairs mostly for selling, promotion and networking activities (Rosson & Seringhaus, 1995). Trade fairs are a highly effective way to gather visitors in one place during a short period of time (Bertrand, 1989). Before choosing which fair to participate, companies should determine the objectives for the participation. Based on the objectives and companies marketing and selling strategies they can choose a fair which has the most appropriate market and geographical appeal. (Tanner & Chonko, 1995; Dallmeyer, 2010.) However, it should be noted that trade fairs have networking aspect as well which actually can be the most important reason to participate especially for SMEs (Evers & Knight, 2008).

Part of the pre-fair analysis is studying the participant list from the previous years after which some kind of understanding is received about attendee behaviour. Pre-fair actions also include plans how to be visible during the fair and how to attract the right kind of visitors. (Cavanaugh, 1976.) Particularly booth space and location, and a wide variety of product mix are means to get visibility also in the case of SME (Williams et al., 1993). Targeting the right audience should start with pre-fair promotion activities. Attendees are highly sensitive for such activities since they make effort to participate the fair and most of them use some kind previews to plan their visit. (Kerin & Cron, 1987.) In case of the most important attendees, it is suggested to send free tickets for the participation (Dallmeyer, 2010).

The booth should be staffed with social and enthusiastic employees with a high level of communication skills. Moreover, they should be given tailored training in addition to general boothmanship education. (Dallmeyer, 2010.) Training helps exhibitors to meet visitors' needs and recognise the role and hierarchical level of a visitor. By estimating these factors the exhibitors are able to adjust their interaction fitting best for the attendees' interests. Attendees in production roles call for different kind of personnel and support material than attendees in managerial roles. (Bello & Lohtia, 1993.) Training can increase only objective knowledge, so experienced personnel is still required in the booth (Bello & Barksdale, 1986).

Classifying the attendees helps also during the follow-up process (Herbig et al., 1998). The easiest way to evaluate attendees is based on time, i.e. how long it takes to conduct a first purchase, and value, i.e. what is the expected value of the first and following purchases (Dallmeyer, 2010). Based on the classification only the most important attendees are contacted immediately, for example in form of e-mail or a sales call (Herbig et al., 1998). If there is no current need for a purchase, the exhibitor should still stay in touch with the prospect and inform it about the latest changes in products and services. In general, the follow-up process is relevant part of the fair participation since most of the sales are concluded after the fair. (Konopacki, 1991.)

Trade fairs are an excellent infrastructure for developing networks (Evers & Knight, 2008). Besides utilising networks for internationalisation in general, they can have a more specific effect on relationship learning during trade fairs. This kind of information sharing within the network can create competitive advantage as collaboration aims to meet the customer's

needs thus strengthening the relationship. Variety of factors influence differently on the sub-processes of relationship learning; information sharing, joint sense-making and developing relationship-specific memories should be recognised as different processes to be able to actively manage them. Relationship-specific memories have the most significant effect for the overall relationship performance outcomes. (Li, 2006.) The relationship management should first consider which relationships to commit scarce resources. Once the decision about the most important relationships is made, efforts should be conducted to change experience, uncertainty, distance and commitment factors of relationships to direction which favours long-term relationships. (Ford, 1980.)

The special features of the Chinese business environment

There are some remarkable differences between Western and Chinese business environments. Being aware of the differences in these cultures is essential for avoiding problems with Chinese companies, labour and public sector. (Hutchings & Weir, 2006.) Cultural habits and business practices, for example, should be known by foreign businessmen aiming to establish business in China (Kettunen et al., 2008). One of the most important issues is guanxi which is deeply rooted in the Chinese culture, and thus reflects its influence also on business environment. Some of the features of guanxi are trust, commitment and reciprocity, concepts that cannot be ignored in relationships with Chinese partners. (Su & Littlefield, 2001.) Guanxi has also influence on choosing between different market entry strategies in China. Regardless of the choice of the entry mode, Chinese partners are needed either in sales, marketing and distribution activities or in the form of JV. (Kettunen et al., 2008.) Foreign companies should somehow be able to denote commitment for their partners but keeping the entry mode as low cost and low risk choice at the same time may turn out to be problematic (Su & Littlefield, 2001).

Synthesis of the theoretical background

The theoretical part listed numerous of factors that influence on SME internationalisation. The degree of the existence of the factors varies from a company to a company. As a result, all the approaches are valid, and different approaches just emphasise different factors. Figure 1 depicts an integrated model of the major factors determining a route to internationalisation. Product or service capabilities, for example, could also be included but the focus is now on these key factors. Discussion about the relation of the factors and trade fairs is quite marginal, although literature provides also some other models about the same topic (cf. Crick & Jones 2000).

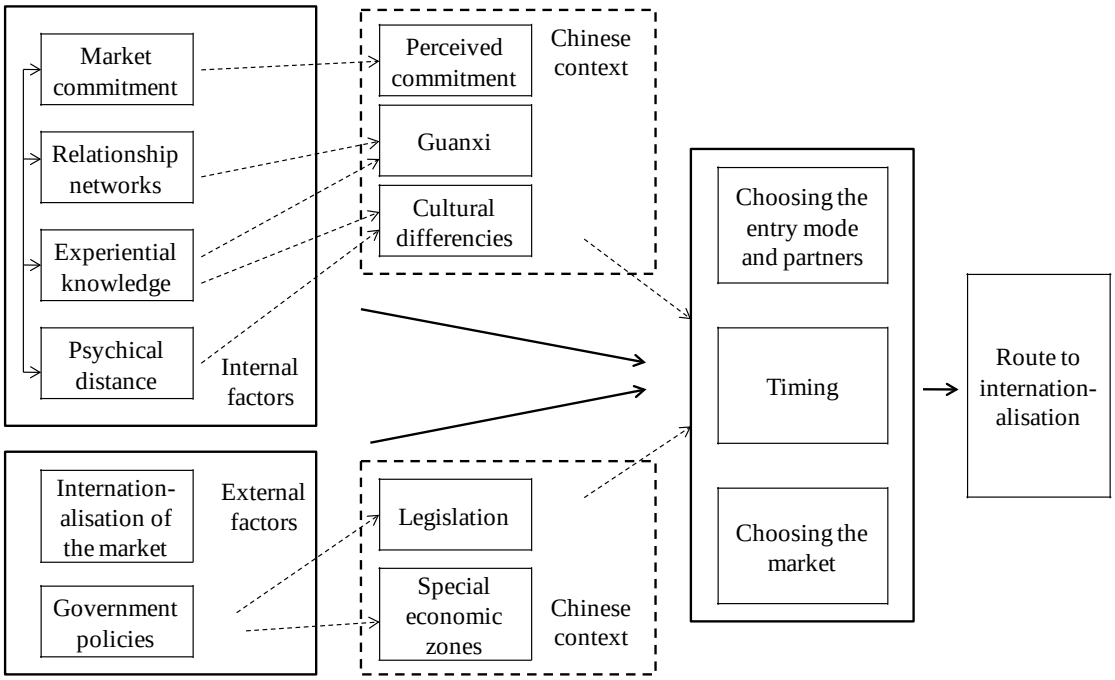

Figure 1: An integrated model of key factors influencing SME internationalisation.

In general, companies decide their internationalisation based on factors that are internal or external to them. The factors affect the choosing of entry mode and partners, the timing of the internationalisation intents and choosing the market. Both internal and external factors are a summary from the literature review, but they are modified by the researchers' own perceptions and understanding. As Chinese business environment is relevant in this case study, it is rational to review the factors from the Chinese point of view as well.

RESEARCH METHODOLOGY

DIEM decided to participate in EU-China Technology and Business Cooperation Fair organised by EUPIC (EU project innovation centre) in China with a delegation including SMEs in the Oulu region. Altogether four companies were involved and they are the case companies in this research. The research is qualitative and uses a case study method. Data is collected through documentation, in-depth interviews in the case companies, direct observation and participant-observation. Analysis and findings about the case companies are influenced by the researchers' perceptions. It leads to having a hermeneutic understanding of the research problem thus ignoring the quantitative methods of research.

Documentation is utilised in the study for example in forms of agendas or letters. Interviews, in turn, are the most significant source of evidence for the study. They are conducted as focused interviews, i.e. interviewer follows certain set of questions, but the situation is still more of an open-ended nature. In addition to the documentation and interviews, also direct observation and participant-observation are used in the study, because the researchers are part of the delegation. Whereas direct observation enables gaining knowledge of some behaviours or environmental conditions, participant-observation allows the researchers also to influence on the previously mentioned matters.

When considering the participant-observation as a source, there is a major problem concerning the close connection between the case organisation and the researchers, which may cause biases affecting the execution of the study. (Yin 2003.) The participant-observation method was utilised only in case companies 1 and 3.

Yin (2003) suggests following three principles for data collection. Using multiple sources is one of the guidelines that assure the evidence to be valid. Second principle is creating a case study data base, which clearly separates the original data by organising and documenting it from the analysed data. And third, maintaining the chain of evidence is necessary when processing the data into a new form of evidence. Consequently, an external observer should be able to trace the path used for processing the data. A case study analysis is considered as the most difficult stage of the whole case study. Problems can be reduced if the researcher develops strategy for analysing the data. Some options are pointed out for high-quality case studies. Pattern-matching compares the predicted pattern with the empirically based pattern. Such a matching would help strengthening the internal validity of the study. The second option, an explanation-building strategy, forms a kind of explanation about the case and aims to discover the causal links related to the case. Strategies should be replicated similarly for all the cases. (Yin 2003.)

EMPIRICAL CASES

Trade fair introduction

The fair was held for the fifth time and DIEM joined the event for the second time. The EUPIC event brings together European and Chinese companies, Europeans mainly as exhibitors and Chinese as trade fair attendees. The participation cost was significantly lower for the case companies than the actual cost was, since the project, which arranged the trip, got funding e.g. from governmental sources. The delegation intended to participate also in other trade fair at the same time at the same place, and it would have included different kind of visitors than the EUPIC event had. However, due to the last moment retiming arrangements of local organisers, the participation had to be cancelled.

The event is not clearly vertical trade fair but it does have clear industrial focus areas, which are IT, new energy, biopharmaceuticals and emerging industries. Altogether two days of exhibiting was included. The fair provided a gala dinner, a cocktail party and several seminars related to industrial focus areas during the six days it lasted. Moreover, the EUPIC organisation introduced the local business environment for example by visiting the chamber of commerce -type of organisation and the Chengdu Hi-Tech zone, and arranged also on-site visits to local Chinese and foreign companies. The event got also attention from the local press due to the international atmosphere of the fair.

The case companies made only few preparations for the fair. In general, DIEM made all the preparations and acted as a link between the companies and the organiser. As such a big delegation, DIEM negotiated itself a large booth with a central location. Requirements of the booth were discussed beforehand. Before the fair, the EUPIC organisation published a book consisting of all the companies and organisations participating in the fair. This was one

of the means to promote European companies to Chinese ones. EUPIC also organised numerous of match-making meetings for each participant. Chinese companies were selected based on European companies' specifications of their expected partner. A database provided by EUPIC consisting of local Chinese companies was to be utilised to find potential companies for the meetings.

Case descriptions

Case 1: Akkuser

Akkuser recycles hazardous batteries and accumulators in an environmentally sustainable manner. The company has full market share of the Finnish battery and accumulator recycling markets and receives material also from the Estonian, Swedish and Norwegian markets. The domestic market yields more than half of its revenues although the share is decreasing all the time. China is a natural target for Akkuser due to the appeal of the market area. Before the fair the company had a few contacts in the country but had not made any business with them. Akkuser has no intents to establish business units to China at least for a few years, though. Currently they are seeking for partners that could ship batteries and accumulators to Finland for further processing.

The company could not send a representative to the fair; therefore DIEM took care of representing Akkuser. Both the discussions at the booth and the match-making meetings were carried out in a way that a Chinese skilled person, i.e. the Chinese employee of DIEM or an interpreter, was present during the discussions. Five long discussions were held at the booth in the first day of exhibiting. Some of the discussions were continued in the next day during the match-making meetings. In general, the value creation model and how the Chinese could benefit from the possible cooperation were the most asked issues during the meetings. The CEO was briefed about all the met companies and Akkuser plans to take the discussions even further.

Case 2: Flowman

Flowman offers solutions that consolidate, streamline and automate business processes in print media industry. The company has strong hold of its domestic market, which constitutes approximately 50 % of its revenues. The rest of the revenue comes mainly from China, where it has two major customers in Southern China in the Pearl River delta area. The company participated in four trade fairs in Central Europe a few years back, but participation was decided to stop. Besides the managerial time they took, the trade fairs were not reaching the appropriate managers within the potential customers; trade fair visitors were mainly technical managers although Flowman would have wanted to contact more CEOs and other executive officers. This time Flowman ignored the short-term sales effect as an objective and instead aimed to get known to the business environment in Western China and establish some relationships in the area.

The company's booth did not have many visitors probably due to its niche industry. The main attention was therefore in the match-making meetings which Flowman had five. The meetings were not believed to completely fulfil the company's objectives, though. Part of

the plan was thus to find a local company that gives on-site visit for Flowman. It was found to be very difficult task because of the special features of Chinese print media industry. One of the local companies in match-making meetings, however, was finally willing to give a short on-site presentation of their operations. As a software company it was able to enlighten the software business in China in general, but Flowman's urge to visit a company from the print media industry still remained. Flowman found three somewhat significant contacts that could be of a long-term interest for the company. The contacts fulfilled only partially Flowman's needs to establish relationship, but the whole event gave insight information about the market area. Nevertheless, the CEO's belief about trade fair usefulness in general was not changed.

Case 3: Hitmedia

The company provides a full platform, i.e. different kind of players, for mobile audio/visual content. Their focus is currently in domestic market, although the company aims immediately for international markets as well. The company's CEO could participate in the trade fair only during the two last days. Decision to participate was a natural choice because of the extensive base of Chinese consumers and low costs of the participation. The goal was to find at least one content provider among producers, copyright owners and artists. Reaching the consumers was thus completely out of scope. Hitmedia targets Chinese consumers primarily outside China and providing content for consumers in China is only part of a long-term plan.

The employees of DIEM took care of all the match-making meetings and exhibiting in general on behalf of the CEO. Since the CEO could not take part in the match-making meetings, five on-site visits were arranged for the next day. The visited companies are SMEs headquartered in Chengdu and were the same ones that joined the match-making meetings. All the meetings followed somewhat the same procedure. First, the participants gave general introduction of their companies. After the introductions, potential cooperation model and some technical issues regarding their technologies were discussed. A general concern in the end of the meetings was how to communicate with each others in the future since no common language existed. Immediate results were generated only with one company, although several contacts were found interesting. Since the company was having problems with piracy, they were hoping for more secure protection and the codecs of Hitmedia could be the solution. A problem is that the company should first create an account but there is only Finnish version of the registration page.

Case 4: Micropolis

Micropolis is a technology centre focusing on micro- and nanotechnologies as well as environmental applications. The company has built a network of other companies from the focus areas and acts as an umbrella organisation for these companies. Micropolis guides and supports its network companies to many collaborative projects which are partially funded by the European Union and its seventh framework program (FP7). Trade fairs are a significant part of Micropolis' marketing strategy. Besides marketing its network companies, it aims to enlarge its relationship networks through trade fairs as well. The network companies of Micropolis are interested of China as potential market area, but China has

remained uncovered for many of those companies. The goal of the participation was thus to gain information about the Chinese business environment. In addition, the company aimed for promoting the company network and finding partners for its projects, FP7-projects particularly.

Micropolis took part in the event exceptionally without its network companies. Booth exhibiting was again secondary compared to match-making meetings. The most interesting booth discussions Micropolis had with some other European companies that were also exhibiting in the fair. Match-making meetings were held five of which two were for Micropolis and others for the network companies. Micropolis had no problems with the arrangements, but conducting business with Chinese was seen a bit complicated. They had problems related to trust since experience with the Chinese was zero and it was thus creating strong prejudices. Because most of the international experience has developed with the Germans, whose culture is close to Finnish one, making business with the Chinese was seen completely differently than with the Germans.

Micropolis joined DIEM delegation to visit one Finnish and three Chinese high-tech corporations, all of them operating in Chengdu. The visits were seen really beneficial because of the insights that they could offer about work conditions, organisation culture and other operational issues essential in Chinese context. Micropolis was also arranged a visit to one of the universities that researches micro- and nanotechnologies. Their goal was to get known to their research topics and results, and make some connections to the university. As already mentioned, the Chinese companies could not offer interesting cooperation opportunities, and results for Micropolis were lame in this sense. They did manage to establish some connections to European companies and non-profitable organisations, though. However, the best cooperation opportunity would probably be with EUPIC, since its already focusing on Sino-EU collaboration.

Summary of the cases

Some of the essential key data of the case companies is summarised in table 1. Almost all the case companies have some international experience. Only Hitmedia is lacking that kind of experience because of recently started business, but the CEO of the company is experienced in international business. In some sense Flowman has the most developed internationalisation process because 50% of its business comes from China, which is culturally a very distant place. International business of the other companies is mainly located in Northern and Central Europe.

Table 1: Summary of the key empirical data.

	Akkuser	Flowman	Hitmedia	Micropolis
International business	Northern Europe, less than 50% of the revenue	50% of the revenue from China, cooperation started in 2007	None	Frequent collaboration with European companies
Trade fair experience	Participates yearly three fairs	Four in Central Europe	Two in Finland	Numerous of participations around Europe
Objectives of the fair	Establishing relationships, increasing understanding of the business environment	Establishing relationships, increasing understanding of the business environment	To find at least one supplier	Increasing understanding of the business environment, promoting Micropolis and its partners
Key actions	Booth exhibiting, match-making meetings	Visiting the Chamber of Commerce and Chinese companies, match-making meetings	Match-making meetings, visiting the potential partners on-site	Visiting the Chamber of Commerce and Chinese companies, match-making meetings
The number of adequate leads	5-6	3	3-4	3-4

Besides sales effect, the companies have understood the possibilities of trade fairs for marketing and networking purposes in their previous participations. It was the same case this time; the objectives of the fair related greatly to establishing new relationships and increasing understanding of the business environment. Hitmedia named a more concrete objective of finding at least one supplier, but it has also the same objectives in the background. One of the key measures that were asked in the interviews is the number of adequate leads. Although it does not tell the whole picture of the fair results and it does not match with all the objectives, it does give some kind of idea of the benefits the fair brought with it. Most of the leads were generated during the match-making meetings.

DISCUSSION

RQ1: What kind of results was gained from the fair activities?

Based on the literature review and on the interviews, the objectives of a fair participant are simplified and classified in four most significant categories in the figure 2. All the categories are practically interconnected to each others in some level, but this fact is now ignored. Depending on the company some objectives are more essential than others, but there are also other factors independent of the company such as the nature of a trade fair that have impact on the potential objectives. The objectives, i.e. preferred results, can be seen as actualised results. The whole procedure in the figure goes actually in objective-action-result sequence, or in other words preferred results-actions-actual results sequence. Even though objectives should affect what actions to choose, the case companies did not have any chance to change the options. They were told that if they join the delegation, they can

utilise the activities depicted in the figure. On the other hand, the options were quite wide so in case of failing to reach the objectives, the lack of activities cannot be accused.

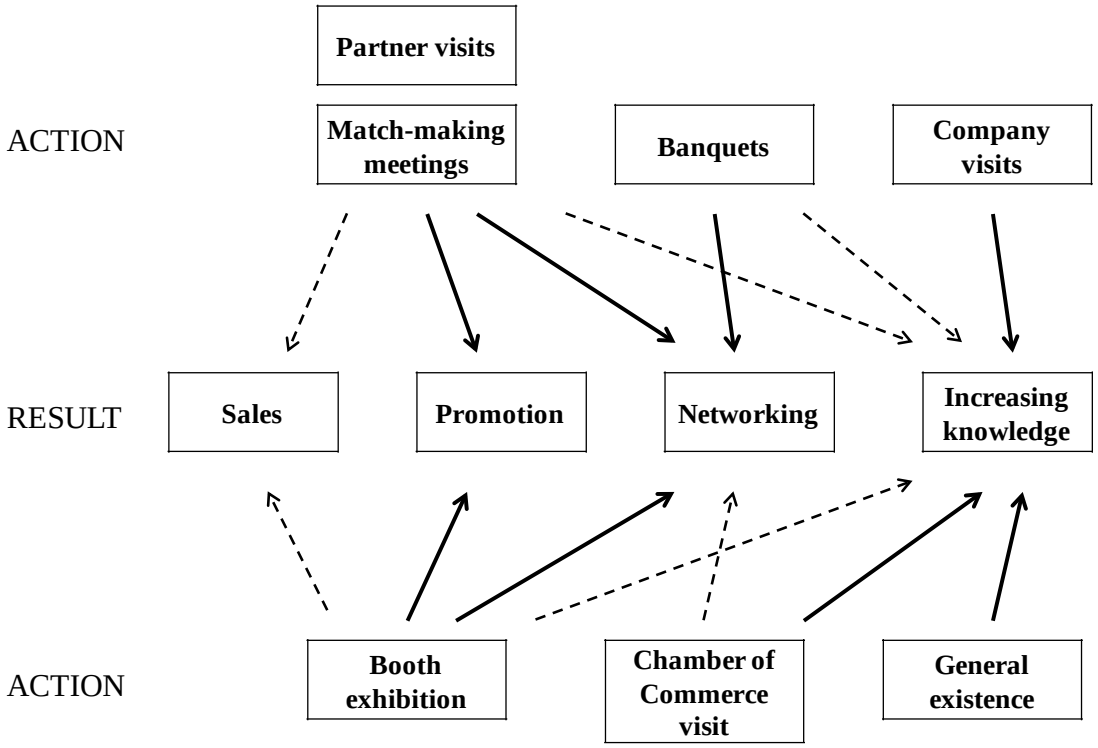

Figure 2: Potential strength of actions to affect the preferred results in the EUPIC fair.

Increasing sales is one of the traditional objectives, but it is usually related to short-term interests. Promotion, in turn, has more long-term impacts. Whether it is promotion about the exhibiting company in general or its products, it may take months or even years before it impacts sales of the company. Networking follows the same pattern, but its most important features relate to getting access to external resources instead of having direct effect on sales. The fourth common objective is increasing the knowledge and understanding of business environment. It asks for understanding the players, i.e. potential customers, suppliers, competitors, public organisations and in general all the players that may have some kind of influence on the focus company, and their connections to each other and to the focus company. Moreover, for example the rules of the environment, i.e. legislation, and processes of the system must also be understood.

The figure 2 depicts the relation of actions and potential results in the fair event, and in this case all the support activities are also included, not just exhibiting. The thickness of arrows corresponds with the relative strength of each action on the results. However, it has to be noted that some of the results are more preferred than others. Therefore the figure is like a mix of theoretical outcome of a situation where all the results are equally preferred and of practice which takes account the nature of the companies and the fair affecting the objectives. For example, because the case companies overlooked the sales objective and its relevance was not high in the theoretical part, its importance is minimised also in this figure. In some other circumstances and with some other companies it would have got more attention.

The figure is mainly based on the researchers' observation during the fair but the interviews of the case study are also utilised. Next, a detailed analysis is conducted about the actions and results, and their relation to the factors introduced in the synthesis of the literature review. Because the objectives of the case companies and their actions were very similar, the analysis proceeds action by action, not case by case. However, some notes are raised from the cases as well if they bring additional value for the analysis.

As the case companies have somewhat long-term objectives for the fair, promotion is generally ranked before sales in importance. Match-making meetings impact thus mostly on promotion and networking; sales may have some kind of effect in the future. Partner on-site visits are seen to have same kind of effects on results as match-making meetings. The meetings and partner visits were quite long, from 30 to 90 minutes, so there is enough time to make initial steps in establishing a relationship and plan future collaboration. The meetings also increase knowledge and understanding of the business environment because of familiarising with the players and learning how they operate in the environment. They could actually have even stronger impact, if the objectives are favouring this matter. For example, Flowman had the on-site visit with one of the companies from the match-making meetings, and the only objective of the visit was to gain information about the media industry in China and find out how it is possible to make business with them.

Two banquets were held during the fair: a cocktail party in the first evening and a gala-dinner in the last day of exhibiting. The banquets were organised by EUPIC and only the European participants and their hosts could join the events. No significant result was gained except for Micropolis who could familiarise with some European companies and non-profitable organisations. Again, the results are very dependable on the exhibitors, and what objectives they set and how strongly they pursue for them. Anyway, an increased network is a probable outcome after a banquet. It can be said that banquets yield also knowledge but it is particularly because of the increased network that acts as a source of information.

Besides Hitmedia's visits to its match-making partners, the whole delegation visited three Chinese companies which were all large corporations in the high-tech industry. These companies and the case companies did not have any interest to make business with each others, but the purpose of the visits was to get known to their success stories, best practices, factory arrangements, etc. As they have years of experience of successful business, they certainly could provide hints how to exploit the huge size of China's domestic market and wide variety of suppliers. The visits were generally found interesting, probably due to their uniqueness as most of the visitors had not visited Chinese companies before, and due to the insight information they offered.

In addition to the Chinese companies, one Finnish company was visited. This visit was a bit disappointment since the Finnish executive manager could not host the delegation as was planned. He was supposed to enlighten especially the challenges the company has encountered in its operations in China. The delegation made also a visit to the chamber of commerce, which gave general introduction about the province and about China's investment policy regarding its western parts, including Chengdu.

The trade fair was quite poor as an exhibition since it could not provide enough visitors. Low traffic was a consequence of the cancellation of another, remarkably bigger trade fair, and the EUPIC event had to act on its own. If the number of visitors had been greater, definitely better results would have gained since several other factors supported this fact. For example, the booth worked well for promotional purposes and part of the case companies raised serious interests at least in relation to the low number of visitors. Flowman is an exception in this sense, because the features of its industry set certain challenges to conduct business in China. Besides promotional results, booth exhibiting could have impacted severely on networking as well, considering again the greater number of visitors. On the other hand, the companies could give much time for their few visitors. The three sub-processes of relationship learning, information sharing, joint sense-making and relationship-specific memories, by Li (2006), can thus be actively advanced, even though all the contacts are new ones. Moreover, as all kind of communication and common activities with the Chinese creates knowledge about the business environment, booth exhibiting cannot be without affecting this matter. Booth exhibiting may also have direct influence on sales in addition to three above mentioned indirect ways: promotion, networking and increase in knowledge. As a conclusion, the role of booth exhibiting as the most versatile tool of trade fairs is valid even if the number of visitors remains low.

During the trip the participants saw and heard things about the Chinese culture and the business environment that improve their awareness and enable them to conclude why certain matters occur in a certain way. Thus the whole trip itself enhances experiential knowledge and diminishes psychical distance to China. Knowledge can be acquired about companies, the city, the country etc. Therefore just by being there company managers can discover new business opportunities or get new ideas for their operations. For example, the vast population of China is often discussed topic in Finland. But when you actually see the masses of people or the technological advances in Chinese cities, it is possible to truly understand the whole potential of Chinese markets. In the end, all the information accelerates the internationalisation process that companies are planning to follow.

RQ2: How the participation could have been improved?

The general idea of the participation was that DIEM takes care of the practical arrangements and consults the companies about their needs and wants if necessary. After the fair DIEM would handle the follow-up if necessary. Figure 3 represents activity of DIEM and an average case company to the whole participation process as the researcher sees it. Only minor differences were discovered in the case companies' activity. The actual, occurred processes are depicted with the solid line and the target processes with the dash line. The participation process is divided in three phases: preparations, trade fair and follow-up. The biggest problems relate to preparation and follow-up phases. Each phase is separately discussed below.

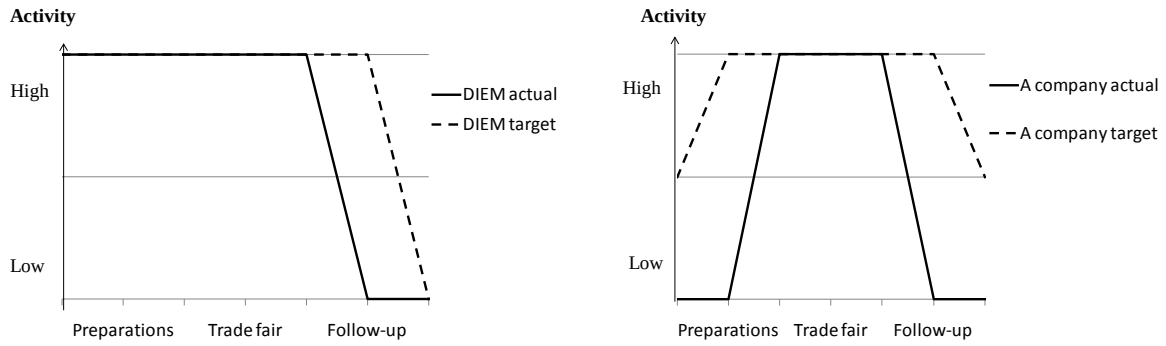

Figure 3: Actual and target activity of DIEM and an average case company during the participation process

The preparation phase

A fundamental problem during the preparation phase was that it was too much on DIEM's responsibility. This was due to the facts that the trade fair event was already familiar to DIEM from the previous year and preparations become most efficient when centrally conducted. Furthermore, the case companies were SMEs, and therefore did not have many resources to be allocated. Managerial time is perhaps the best factor to depict the low commitment but also the participation price, which barely covered the transportation costs, made the participation supposedly too effortless. The reason why commitment of the participating companies should be increased is not that DIEM needs more help with in the preparation phase. Instead, if the companies are planning to continue their business in China, they should consider the learning possibilities that the whole participation process, not just the fair itself, provides. Someday, they may have to arrange the whole participation by themselves. Hence, DIEM should somehow increase duties of the participating companies if this kind of delegation will be organised again in the future. The suggested activity increase during preparation phase can be seen in the figure 3.

In conclusion, there are several conditions for the actions the companies should conduct. First, the actions should enhance learning experience. Second, only small amount of resources can be allocated. And third, the efficiency of arrangements should not be remarkably affected. On the other hand, the learning experience must be absolutely higher with bigger amount of resources allocated.

Eventually, the above mentioned problem is actually finding a balance between learning experience and the allocated resources, still paying attention to the third point and to the fact DIEM's preparation actions made the joining quite trouble-free. All the case companies and their managers in the fair have participated fairs before. Consequently, training concerning trade fair participation in general is not the top priority even though it was mentioned in the theoretical part. Instead, as part of the managers have only little experience of the Chinese people or culture, training in this regard is necessary. It allows the managers to focus on essential issues during the fair and make observation on things that they know may yield long-term benefits as form of experiential knowledge. DIEM could easily take care of the training as it already is somewhat experienced trade fair visitor (altogether second participation in this fair) and has knowledge about the Chinese business

environment. Another trainer party could be companies that have already conducted some business in China. These companies could be exploited as mentors to share some detailed hints and experiences of challenges and opportunities in China.

The database provided by EUPIC could be another tool to increase companies' efforts during the preparation phase. The database included potential match-making partners, but it was utilised only in small scale. Although the case companies gave their preferences of the partners they wanted to meet, it would have been significantly more efficient if the companies had looked them thoroughly through. Further, they would have familiarised themselves with the partners they are going to meet.

As the database listed Chinese companies based on their industrial segment, it could offer further business opportunities. The database consists of companies seeking European partners for customers, suppliers, R&D collaboration etc. Thus, Finnish companies could also take partners from their supply chain to exhibit in China. In a big picture, companies or clusters that can provide complete solutions are highly valued in China. If the Finnish companies realise the synergies that a cluster could bring, their chances to succeed are naturally higher. Finding synergies for the participating companies is a topic worth to pursue also for DIEM. This time, the case companies were all from different industrial segments.

Before participating in trade fairs companies should prepare themselves for international business, unless they are participating purely for experiential and informational reasons. In general, the companies should find out how far their internationalisation process is and decide if a trade fair can benefit the company in its current state. Accordingly the companies should devise strategies and business models for international business. Whether they have the strategy or it is still open, the objectives of the fair should follow these matters. For example, Akkuser had not decided its business model for Chinese markets, and therefore its objectives related to finding out information that may help to determine the model. Knowing the Chinese, the fastest, and maybe the most risky, way to get truly functioning business collaboration is to establish a representative office or even a production facility. They are great ways to denote commitment, which is a key to a long-term relationship.

The participating companies should also mind their facade, i.e. web pages, marketing material etc. Hitmedia is a good example of the problems that may occur, if web pages are not finished. As mentioned in the empirical part, Hitmedia did not have Chinese web pages (the same situation with all the case companies), nor it has English version of the registration page so that the Chinese partner could upload content to the web pages. Creating Chinese web pages does not ask for lots of effort, but they may have huge impact on the credibility of a Finnish company and on getting business immediately started. As the web pages are often the first thing to check from the company and English is still poorly understood in China, Chinese web pages are almost a necessity for successful business in China. At least they can remarkably accelerate the business.

Trade fair phase

No significant problems, which could have been avoided, occurred during the fair. For example, Akkuser did not have a representative, but it was unavoidable. The following

improvement suggestions may gain significant results, depending on the company and the fair it is participating. The suggestions are considered bearing in mind the "impact-resource"-ratio, i.e. producing efficiently as high results as possible with minimal resources.

Each case company utilised some kind of support material, often their own PowerPoint presentations, during the booth discussion and the meetings. They affected positively the fluency of the discussions and meetings as they could send a clear and consistent message for the counterpart. In addition, the interpreter's work was eased with the presentations. Interaction in general was quite smooth although there were concerns in Akkuser's and Hitmedia's case that how credible representative DIEM, as a university, would be.

A major disadvantage was the missing CEO of Akkuser. The discussions and the meetings went reasonably smoothly even without the CEO, but the problem lies in the fact that the learning effect was quite minimal inside the company. Some notes have been sent to Akkuser to transfer experience and gained knowledge, but the knowledge transfer process can never be wholly completed. However, Akkuser has already some experience of the Chinese business environment due to the fairs it has been participating in China. The minimal learning effect is thus not that critical.

The missing CEO has more remarkable impacts on the relationships to the Chinese leads, though. Currently, the relationships are established between the DIEM employees and the leads. If the leads are still satisfying, relationships should also be established between the CEO and the leads. The trade fair would have been a great platform for this purpose since it enables information sharing, joint sense-making and developing relationship-specific memories, the key issues in relationship learning. Now the DIEM employees experienced these issues, but this kind of experience is rather difficult to transfer. There have been plans that DIEM takes care of the follow-up for Akkuser since the leads are already familiar and Chinese language is needed in the communication.

Visitor classification is one of the important topics emphasised in the theory. None of the case companies practiced concrete classification, where they qualify their leads in some kind of lead form. However, as the number of leads remained low for all the case companies, the absence of classification system does not have a major impact on the coming follow-up work. Anyway, creating some kind of lead classification system requires only little effort, but may become essential if the number of visitors is expected to be greater. Simply put, leads could be qualified based on money and time factors, as discussed in the theoretical part.

Follow-up phase

Figure 3 notes that there is much to improve in the follow-up process. A key notion is to recognise that there is no planned and systematic follow-up-process. A few leads were contacted immediately after the fair, but only by DIEM. Follow-up was not on DIEM's responsibility but contacting the leads was seen to happen most conveniently in this way since DIEM already knew the leads and there was no language barrier between DIEM and the leads. DIEM and the participating companies should decide already in the preparation phase about the follow-up so that the transition to follow-up phase would be fluent and

immediate. Moreover, if a company has implemented a lead classification system, it can help to focus on the most important leads immediately after the fair.

DIEM could compile a follow-up manual of guidelines and best practices during the follow-up phase, no matter if it is DIEM or the participating companies that manage the follow-up process. If there is a language barrier between Finnish companies and leads, DIEM could take care of the follow-up phase. However, the companies should be involved in some level already in the beginning and gradually increase their responsibility so that after a while it is actually greater than DIEM's (figure 3). This is because of the same reasons why Akkuser would have benefitted more if their CEO had participated: the learning effect and established relationships. All kind of communication and collaboration with the Chinese enhance learning about conducting business in China. Later, it is easier to start business and no intermediates are needed. Furthermore, follow-up is a way to deepen relationships and if DIEM continuously contacts the leads, there is a danger that no relationship will be established between the Finnish companies and the leads. The follow-up phase should include continuous contacting with the leads, not just in the beginning. Contacting the leads for any purpose is recommended because it is a way to tell that the company still exists and is willing to collaborate with the lead.

Summary of the research question 2

Figure 4 summarises problems that occurred during the whole participation process. The problems are categorised based on their severity and how easy they are to fix with scarce resources. In the upper right corner are the problems that should undoubtedly get attention. The upper left and lower right corners are also essential. The problem in lower left corner refers to the low number of visitors. It is not very severe since the event provided so versatile side activities and the low number was just an exception because of force majeure reasons. On the other hand, the fair could be changed to some other one, but the good relationship to EUPIC remains the inputs of participation quite low. It is thus difficult to find a more efficient fair especially if the objectives of the case companies relate to promotional and networking matters. A participating company should always find out if its objectives match with the opportunities provided by a fair.

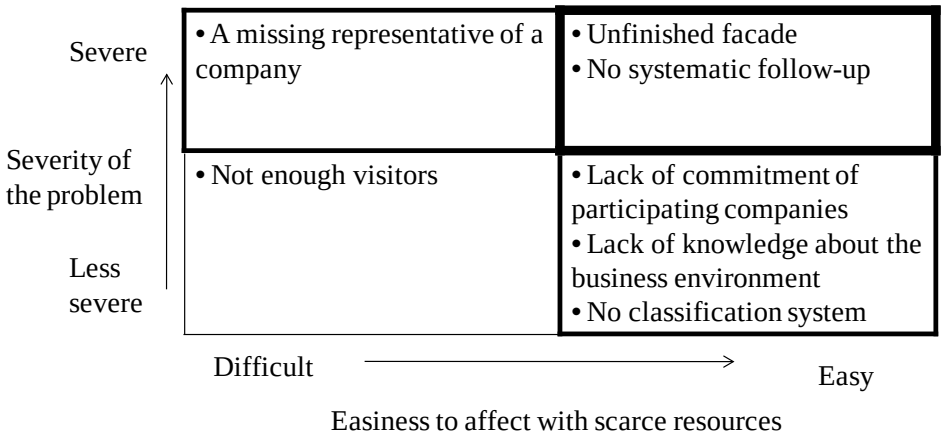

Figure 4: Problems during the participation process

Based on the previous figure, table 2 summarises the tools and actions that should be carried out to solve the problems occurring during the participation. The table presumes that DIEM will organise another delegation to Chengdu, and therefore part of the actions are on its responsibility. Nonetheless, most of the actions can be applied also to companies that are participating in a fair just by themselves.

Table 2: Summary of the improvement tools and actions

Problem	Tool/Action	Accountable
lack of commitment of participating companies	training about the Chinese business environment	DIEM
	finding out match-making partners	companies
lack of knowledge about the business environment	mentoring help in Finland or in Chengdu	DIEM, companies
	cultural training	DIEM
unfinished facade	Chinese web pages	DIEM, companies
	translating other marketing material in Chinese	DIEM, companies
a missing representative of a company	knowledge transfer	DIEM
	involving the company during follow-up	DIEM
no classification system	creating classification system	companies
no systematic follow-up	follow-up manual	DIEM, companies
	starting plannig already before the fair	DIEM, companies
not enough visitors	checking the objectives vs. fair opportunities	companies

Limitations and topics for further research

The case study includes matters concerning only Finnish SMEs. Therefore, it is not straightforward to apply the findings of the paper in companies from different countries. However, as the study was mainly carried out in international stage, the findings can be estimated to be applicable for foreign companies as well, at least for western ones. Next, applying findings in multinational enterprises that already have established their position in the international market is also somewhat precarious. A third limitation is the small amount of the case companies which constrains the generalisation of the findings. And finally, since the Chinese business environment differs significantly from the western one, findings from a Chinese trade fair can differ compared with findings from a western trade fair as well.

As generalisation is a problem in this study, findings are more like guidelines due to the explanatory study. Further studies in similar conditions are needed to verify the results of the study. A study with the same companies is not rational, though, since the situation would not be unique anymore. Figure 1 could also be an initial step for further studies, although similar kinds of studies have already been made. It should be found out that which internationalisation approach' managerial implications fit best for the Chinese context and the effect of internal and external factors on entry mode. For example, international new ventures are one of the newest approaches but they partially ignore psychical distance which is an important determinant in the Uppsala model.

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MANAGING SOURCING PROCESS WITH CHINESE SUPPLIERS – A CASE STUDY OF FINNISH COMPANIES

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ABSTRACT

The paper analyzes five Finnish case companies to study the sourcing process from China. A framework of a six-stage sourcing process is developed which include finding and choosing supplier, making contract and orders, production and quality control, logistics, purchasing inspection and the development of supply chain management. Each stage describes the activities from the channels of seeking suppliers to the cooperative areas for further development. The case study illustrates the practices of sourcing from China are actually quite similar with the sourcing process in other countries. The study highlights that quality control is the core issue in the process of sourcing from China. Moreover, the difference in understanding of sustainable quality affects the activities of supplier screening and quality control. Close cooperation on quality control is the key activity to manage supply chain in order to increase the competitive advantage through sourcing in China.

Keywords: sourcing process, Chinese supplier, case study

INTRODUCTION

Managing the purchasing task in the supply chain has been a challenge in the last decade for many corporations (Karpak et al. 2001) Supply chain management is not just a domestic phenomenon. Supply chain transcends national boundaries, imposing the challenges of globalization on managers who design supply chains for existing and the new product lines (Meixell & Gargeya 2005). The catalyst for global sourcing has been the worldwide competitive pressure forcing firms to reduce costs and to improve quality and responsiveness (Gelderman & Semeijn 2006). Global supply chains are more difficult to manage than domestic supply chains. Substantial geographical distances in these global situations not only increase transportation costs, but complicate decisions because of inventory cost tradeoffs due to increased lead-time in the supply chain (Pennanen et al. 2011).

Interest in China has soared in recent years because of the booming economy (Pyke et al. 2000). Due to economic growth of China and the increasingly global competition, China is gradually becoming an attractive sourcing destination rather than merely a market for many foreign companies (Campbell et al. 2004), especially in the case of manufactured products and components (Enderwick 2009). Moving the sourcing activities to China is a challenge for the foreign companies because of various difficulties, such as intellectual property infringements, customs delay, poor communication between headquarters and suppliers (Campbell et al. 2004); quality fade ((Enderwick 2009); unpredictable inflation rates, problems of government intervention (Mentzer 2001); and long geographic distance and increased delivery time (Fredriksson & Jonsson 2009). Although low cost is main motivation for sourcing in China (Salmi 2006), the degree of cost advantage is also a concern (e.g. Salmi 2006) when decreased delivery precision may increase costs in terms of expedited freight, unfulfilled demands, extra inventory, and managerial time spent on "fire-fighting" (Fredriksson & Jonsson 2009).

Although many hurdles are in sourcing from China, well organized procurement practices is a source of competitive advantage when the foreign companies have strong ties to supplier in China and adopt best practices that cut operating costs and improve lead time (Campbell et al. 2004). Therefore, mapping a good sourcing process is an important concern for the foreign companies when moving sourcing activities to China. The question of "how to start and operate" is usually proposed by many practitioners taking advantage of cost competitiveness.

Zhang & Goffin (2001) summarize that research focuses of supply management are in the areas of supplier selection and evaluation; sourcing strategy; developing relationships with suppliers; contextual issues influencing supplier management; and supplier management in Chinese IJVs. The study of Zeng (2003) shows that there are very limited studies on sourcing process design and management. This paper focuses on the sourcing process of supply chain management (SCM) with Chinese suppliers. The research questions are how to develop sourcing activities with Chinese supplier and what the activities of the sourcing process from China are. The scope of the study covers from the channels of finding suppliers to the interactions in the sourcing process. The objective of the research is to develop a framework of sourcing process based on the experience of Finnish case companies with Chinese suppliers. The purpose of the study is to facilitate the sourcing process of supply chain management.

The rest of the paper is organized as below. The part of literature review presents some studies on sourcing process. The section of research design introduces the selection of research methodology, the collection and analysis of data. Then, cross-case analysis is discussed after the empirical study describes the practices of five Finnish case companies sourcing from China. The final part consists of the concluding remarks, research limitations and further study.

LITERATURE REVIEW

Supply chain management is the integration of key business processes from end-users through original suppliers that provide products, services, and information and add value for customers and other stakeholders (Min & Zhou 2002; Cooper et al. 1997). SCM is the process of managing relationships, information, and materials flow across enterprise borders to deliver enhanced customer service and economic value through synchronized management of the flow of physical goods and associated information from sourcing to consumption (Mentzer 2001). Purchasing is one of the strategic functions with the highest potential impact on a firm's long term profitability (Quintens et al. 2006). Van Weele (2005) defines purchasing as "the management of the company's external resources in such a way that the supply of all goods, services, capabilities and knowledge which are necessary for running, maintaining and managing the company's primary and support activities is secured at the most favorable conditions". The scope of purchasing has increased from buying operations to supply management (Salmi 2006).

Referring to Van Weele (2005), procurement, purchasing, sourcing and supply management can be used interchangeably. Therefore, the terms are homogenous in this paper.

Quintens et al. (2006) conceptualized the purchasing process, and defined four phases: (1) the investigation of purchase markets and the screening of potential suppliers, (2) the selection of supplies, (3) the negotiation and contraction, and (4) supplier evaluation and follow-up. Coordination of purchasing encompasses the creation of purchasing synergies from economies of scale, scope, process, and learning.

Van Weele (2005) illustrates the main activities within the purchasing function and the purchasing process model (Figure 2). These activities aim at (Van Weele 2005):

- Determining the specification of purchasing goods and services in terms of required quality and quantities.
- Selecting the best potential supplier and developing mechanism to be able to do this.
- Preparing and conducting negotiations with the supplier in order to achieve an agreement and the legal contract.
- Placing the order with the selected supplier or to develop efficient purchase order and handling routines.
- Monitoring and control of the order to secure delivery.
- Follow-up and evaluation on the elements of setting claims, keeping product and supplier files up-to-date, supplier rating and supplier ranking.

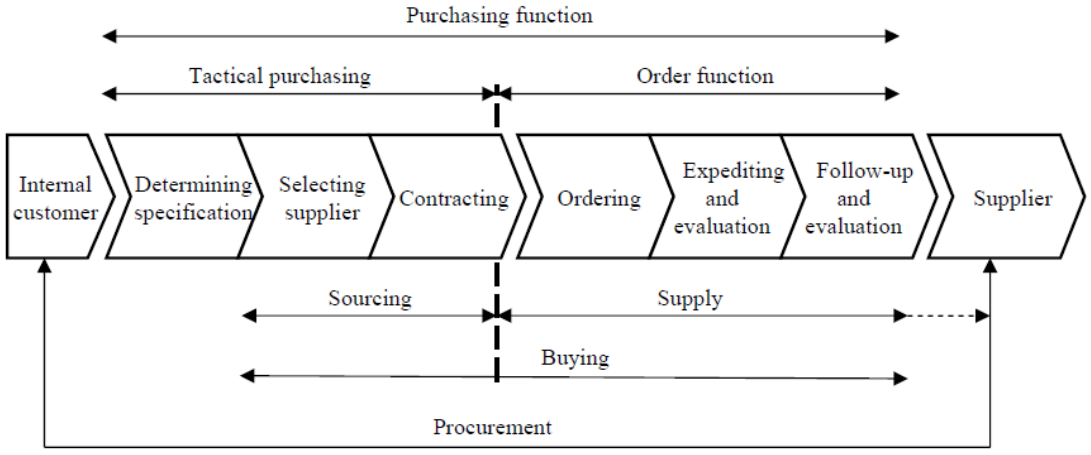

Figure 1: Purchasing process model (Van Weele 2005).

Zeng (2003) summarizes some studies on the sourcing process to form a five-stage sourcing process, which includes investigation and tendering; evaluation, supplier selection & development; implementation and performance measurement & continuous improvement. Figure 1 lists the activities in each stage of the sourcing process.

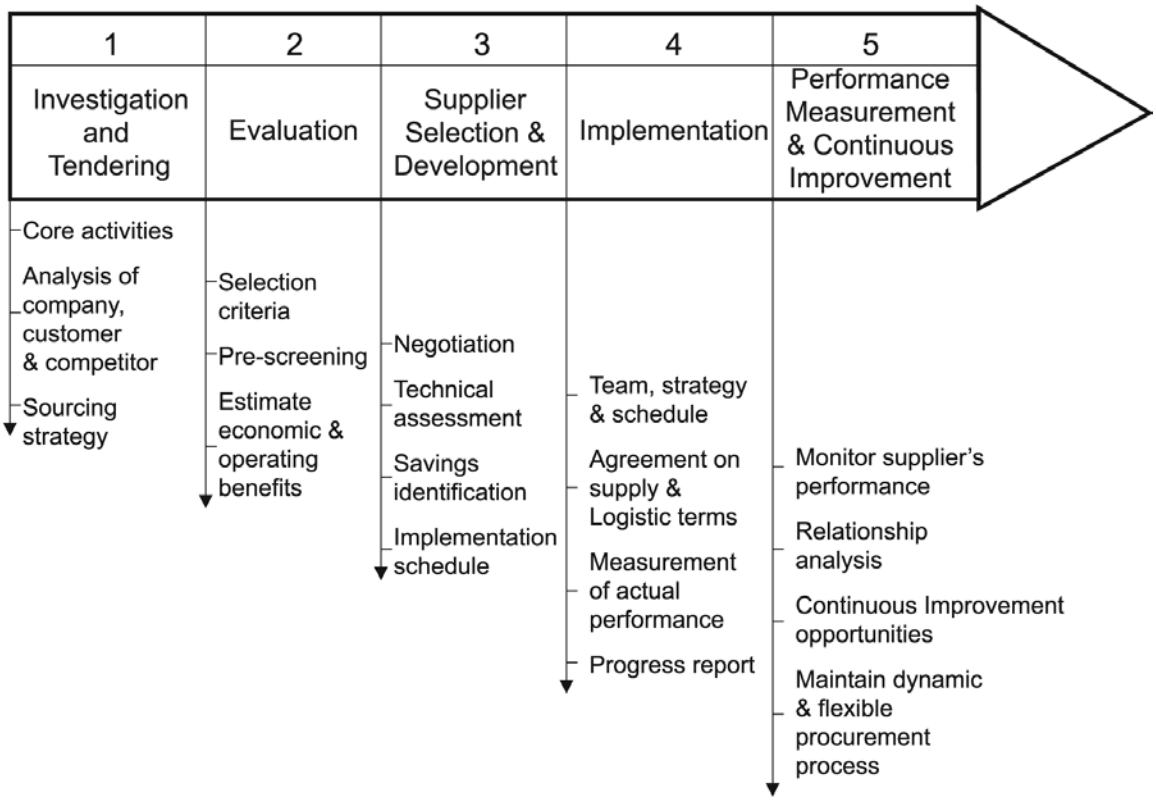

Figure 2: A generalized five-stage sourcing process (Zeng 2003).

Trowbridge (2006) identify eight optimal stages of sourcing process, which include preparing for strategic sourcing, profiling the category, developing category sourcing strategy, generating supplier portfolio, competitive selection or supplier development, selecting competitive suppliers and negotiate, implementation and continuous improvement. Trowbridge (2006) lists a set of activities in each stage which are believed to progress a solid sourcing process. Table 1 lists the activities of each stage.

Table 1: The stages and activities of sourcing process (Trowbridge 2006).

Stages	Activities	
Preparing for Strategic Sourcing	• Do we have a sourcing project? • Selling early procurement involvement • Internal customer needs – a comparison of needs • Internal customer relationship management • Common procurement myths	• Developing a marketing plan • Internal customer marketing support tools • Establish steering committee & sponsor team • Establish cross-functional team • Project plan preparation
Profiling The Category	• Getting started with the strategic sourcing process • Defining the sourcing category • Identify basic category characteristics • Collect and analyze basic information • Expenditure analysis • Request for information (RFI) • Stakeholder interviews	• Process review and mapping • Total cost of ownership identification • Cost reduction/opportunity development • Market analysis • Market segmentation identification • Defining balance of power in the supply market • Sourcing category evolution
Developing Category Sourcing Strategy	• Definition of sourcing strategy • Category positioning matrix • Factors determining buyer power and category criticality	• Opportunities for creating value from strategic sourcing • Strategic sourcing approach • Positioning the sourcing category
Generating Supplier Portfolio	• Supplier portfolio generation • Developing the candidate supplier list • Supplier types • Supplier capabilities • Source location • Supplier profile • Identification of potential suppliers	• Developing the short list of prequalified suppliers • Evaluation criteria and methods • Data collection • Request for information • Supplier evaluation summary • Stakeholder “buy-in”
Competitive Selection or Supplier Development	• Selection of implementation path • Identification of preferred supplier(s) • Supplier development and the strategic sourcing process	• Supplier development constraints • Negotiation strategy – competitive vs. collaborative
Selecting Competitive Supplier(s) and Negotiate	• Preliminary strategy formulation • Proposal generation • Developing the request-for-proposal (RFP) • Proposal solicitation and evaluation • Potential post-bid problems • Post-bid strategies	• Negotiations overview • Negotiation goals • Negotiation strategies and methods • Preparing for negotiations • Negotiation tools • Negotiation process
Implementation	• Key implementation activities • Key implementation factors • Cross functional team roles and responsibilities • Communication needs	• Cost savings calculation and tracking • Savings spend baselines • Cost savings tracking key elements • Savings calculation methodologies • Utilizing the market basket approach

	• Communication methods • New process implementation	• Baseline savings reporting approaches
Continuous Improvement	• Continuous improvement activities • Continuous improvement monitoring • Key contract administration players • Tips for pro-active contracting • Monitor performance – benchmarks	• Progression in supplier relationships • Supplier performance rating system • Supplier performance criteria • Supplier performance reporting • Benchmarking

Literature review shows that the studies classify the stages in the sourcing process (e.g. Quintens et al. 2006, Zeng 2003, Van Weele 2005) and identify the activities in each stage (e.g. Trowbridge 2006). The major stages of the sourcing process include supplier selection, purchasing implementation, performance of supplier measurement and further development. Trowbridge (2006) provides a detailed check list of sourcing process on the practical level. The stage identified by Trowbridge (2006) comprises more preparation activities on strategic level and an in-depth analysis of internal sourcing management.

RESEARCH DESIGN

Research methodology

The paper proposes "how" question to study the supply chain management of the Finnish companies when using Chinese suppliers. The research intends to reveal descriptive and exploratory information in order to understand the practices and process of the supply chain. The research purpose leads to choose qualitative method first to better understand the phenomenon remaining unknown; second, to gain new perspectives on matters already well known; and third, to gain more in-depth information that may be difficult to convey by quantitative means (Strauss and Corbin 1998).

Case study is a typical qualitative method to conduct on "how" or "why" questions, especially when the investigator has little control over the events or, when boundaries between studied phenomenon and real-life context are not clear cut (Yin 1994). In the study, a multiple-case approach is utilized. The purpose to using multiple cases is to produce analytical generations of the findings (Yin 1994).

Case companies

There are five case companies from Finland in the study. Four are located in Vaasa region and one in Vantaa. The case companies are contacted by two authors of the paper. The case companies in Vaasa region were selected only on the condition that the case company conducts sourcing activities from China without any own subsidiary in China. The case company in Vantaa was from a project work to study the internationalization process of Finnish company to China. The case study found that the company mainly conduct sourcing activities from Chinese suppliers. A representative office was established in China after 17 years sourcing from China. The company has sourcing experience from China for about 20 years. The four case companies

in Vaasa are SMEs. The one in Vantaa is a group company. All the case companies are in manufacturing industry (Table 2).

Data collection

The data are collected through interviews with the management personnel or the owner of the case companies. Table 2 lists the relevant information of the case companies and the interviewees. The names of the case companies and the interviewees are not disclosed in the paper.

Table 2: Case companies and interviewees.

Case company	Business area	Souring items	Interviewee
Case A	Sports clothes	All tailor-made clothes	One of the owners
Case B	Plastic components	Moulding production	Project manager
Case C	Product development service	Semi products, cables, parts and connectors	The owner of the firm
Case D	Cabin of agrimotor	Metals, glasses, tire products, coupling gears, steering wheels, lights etc.	Purchasing manager
Case E	Machine building	Tailored products and standard products	Managing director

Two questionnaires were used in the data collection. One questionnaire was used for four case companies in Vaasa region. The other questionnaire was used for the case company in Vantaa. The reason was mainly due to the researchers had focused on different aspects of project tasks at the moment of conducting the interviews. Despite the different means, the paper utilised the five cases as they arrived the same end to reveal the practices of sourcing process with the Chinese suppliers. All the interviews were conducted in the companies' premises in 2010.

Data analysis

The paper is a part of project and a combination of a Master thesis work and the project work. The four case companies in Vaasa region were analyzed through a theoretical framework in the Master thesis developed by one of the authors. The Master thesis is regarded as a report of case study as it provided detail description of the case companies and their practices of sourcing from China. The analysis of the case company in Vantaa was follow the same analysis framework of the other four case companies in order to keep construct validity by establishing chain of evidence and having key information from the interview transcription (Yin 1994). This paper focuses on the practices of sourcing process of the case companies. The theoretical part of the paper is developed based on the specified topic.

EMPIRICAL STUDY

Case A

Case A is a Finnish company that specializes in clothes that are especially adapted to fit the customers' needs of training and competing. The company works closely with different athletes and sports clubs in order to make custom made training- and racing clothes. It makes design work according to the customer needs. The company purchases all sporting clothes designed for the customers. So far, it has five suppliers in China.

Originally, the company purchased sporting clothes from Estonia in 1999. The price level started to grow very quickly after Estonia became member of EU (European Union). The company started to swift supplier from Estonia to China because of the low labor costs, material costs and Chinese know-how of garment industry.

One owner of the company had a friend working in China. Choosing the supplier was quite easy because the friend in China was familiar with the culture and had connections to the Chinese supplier in garment industry. The company started the collaboration with Chinese supplier in 2004. According to the company, it is good to have a local partner because they usually know how to do business with Chinese. The best way to find trustworthy supplier is by creating contacts with Chinese people. In Chinese culture, relationships are highly respected. Local people may know someone, and that person knows someone who might be important person in finding a decent supplier. Local people may have really strong ties with centrally placed actors in that specific industry. Also a good way to find a supplier is to go through different fairs and, for instance local website, (www.alibaba.com), where all the suppliers are listed.

Even though the cooperation with Chinese suppliers has been success, there are still quite much complexities and problems. Chinese people are not so assertive as compared to Western people, especially Finnish, and they don't always keep their promises. The company takes care of quality control itself. The company has one employee in China who visiting once in a week in the factory. He makes sure that the clothes have the right quality. The finished clothes are not leaving from the factory without quality control.

Delivery reliability is a problem all the time. Deliveries are usually late, and then company and the supplier have to decide who is paying the cost by delay. Clothes that are delivered to sports clubs goes first to Helsinki and then to customers. Those clothes are not going through the company. Clothes that are delivered to retailers go first to the warehouse of the company and further to customers after the quality control. The company takes care of research and development. It does not have collaboration with supplier in that area.

The company has two market segments – sports clubs and retailers. Sports clubs' orders are usually easier to handle, and the order to the supplier is done via email. The delivery time is approximately two months. More complexities are including in the retailers orders. Retailers are usually sports stores and they want to sell their own inventory first before they are

willingness to order more. This causes problems to the company because they should know as early as possible the retailers' orders. The order should come at least nine months before the delivery, but usually the company receives the order six months earlier than the desired delivery time. Therefore, it is quite complex to make the orders on-time.

Several things that could develop the supply chain between Chinese suppliers were found by the company. Automation is one of these. It was hoped that in the future the company could control the manufacturing process. It would clarify how the process is going further and when the delivery is going to be late. At this moment it is not possible and usually the late delivery is informed too late. Information goes via email and the company doesn't have an access to suppliers' databases. It takes a lot of time and effort to maintain good relationships with suppliers but it is worth it. The company is planning to build up an own factory and own brand store but these are only in the planning phase.

Case B

Case B is a manufacturer offering injection and reaction injection moulded plastic parts from single products to part assemblies. The company purchases moulds of ready for the production from China. They also purchase different raw materials and so on, but mostly the focus is on moulds.

The cooperation with Chinese suppliers started because of the growing competition. The company needed to be cost effective as well when competitors were purchasing cheaper from China. At the same time, the volumes started to grow; outsourcing has been very effective way to handle the situation so that the company has been able to concentrate on service, product changes and product development.

Originally the company had purchasing activities from other countries, but nowadays all these activities are focused on China. Motivation for purchasing from China was based on costs, the lack of suppliers in other countries, delivery reliability, precise culture, Chinese huge efforts of their way of working and knowledge of technology. The Company participated in industry fairs in China. They also searched suitable suppliers from the internet, and in that way they found the most qualified suppliers. Nowadays the company has wide connections to China but only couple of key suppliers, mostly in Shenzhen.

The company has only positive experiences of cooperation with Chinese suppliers. They have long-term relationships with suppliers and the cooperation is working smoothly. The company believes that it is important to visit in China and see the suppliers face to face. The most important factors when doing business with Chinese companies are quality, price and the fluency of cooperation. According to the company, working with Chinese is fluency, flexible and organized. Chinese are also taking care of documentation coordination and that is very effective and well organized. That is especially useful when something needs to be checked. The amount of suppliers has grown but the company still has, more or less, cooperation with all its suppliers.

Even though company has key suppliers, it is purchasing every now and then from other suppliers to keep the cooperation alive. The purchasing process starts from customer's order. First the company discusses with customer and finds out customer's needs. This is an impulse that needs to happen before purchasing activities from China can start. Delivery times are usually more than five weeks, but with the most complex parts the delivery time can be eight to nine weeks. The company hasn't had any problems with delivery times and the deliveries happen when they are supposed to happen. Company receives the report on weekly basis from the suppliers about the progress of manufacturing process and usually the company knows when the delivery is going to happen. Information sharing is handled via email or Skype. That is the easiest and the cheapest way to communicate. It is also easier for Chinese to use email, because their written English is much better than the spoken one. Every key supplier has own contact person who is speaking English and Mandarin, and who can translate all the needed information. That person is also acting as a link to the technical personnel.

The company is taking care of logistics and they are using both sea transport and air transport. The way of transportation is choosing according to the weight and size. The bigger parts are transported by shipping, because it is much cheaper than flying. Logistic decisions are made by case-by-case. The cost of the transportation varies according to who is booking the transportation. Usually it is cheaper when the booker is Chinese. They are not using couriers but they are booking straight from the shipping company. This means that they also have to take care of taxes and customs. Chinese suppliers are delivering products to the harbor but after that the responsibility transfers to the case company. The company and its suppliers have no access to each other's databases, and the impulse to the purchasing comes from customers' order. The company is doing collaboration with Chinese suppliers in R&D. the case company is sending raw materials to China for testing. After testing, Chinese suppliers are sending these test parts back to Finland with testing reports. In Finland, moulds are having another test drive before the implementation and transferring to the production.

The case company has specified the quality strategies for all its suppliers and how they should work to fulfill the quality requirements. Suppliers are sending different kind of quality documents to the company when needed. The case company is taking care of quality controlling when the products are arriving to Finland. For the ready products the case company is doing different kind of quality measurements, for example hardness measurements. The case company is very satisfied to the cooperation with Chinese. They don't have any specific development areas in mind, but one suggestion would be recruiting own employee to China but that is only development proposal.

Case C

Case company C offers product development services primarily for companies that design and manufacture electrical equipment. Additionally, the company produces and sells its own ergonomic and energy efficient products. The company purchases different kind of semi products, cables, parts and connectors. Purchasing part of net sales is approximately 3000 Euros and China's part of this is 500 Euros. Western firms are not offering qualified suppliers

and that's why the company had started to find suppliers from Chinese markets. The company has searched suppliers from the internet and has contacted the companies that would be the most qualified. Contact has happened via email. Because the amounts of orders are not so significant, the company feels no need to visit in China. Email is the best way to communicate with Chinese and they are very active in that field. The case company has now only one supplier. It uses couriers for logistics. Couriers are taking care of taxes and customs and they are transporting products from door to door.

The case company is now developing and producing its own products and has a lot of ideas for the future. The company has now purchased USB-cables from China and the production is going to start in Finland. The company has a stockpile because it is easier to purchase larger batches at the same time. According to the company, it is very important for Chinese to visit in China and see the supplier face-to-face. Now when there has only been one supply from this supplier, it is not yet necessary to go and visit in China but if the cooperation continues it would be the next step in the development of cooperation. The company just trusts that the supplier can handle its work. Quality control takes place in Finland when the components have arrived. The company does not have an employee in China who could take care of quality control. It has just buyer-supplier relationship with its supplier and they are not doing more collaboration.

The biggest problem in collaboration with Chinese is communication. Chinese people are not speaking English very well and they are not so willing to take advices from another people. Quality, price and Chinese active way of working are still the biggest reasons to choose Chinese supplier. Chinese people are also very friendly and it is nice to collaborate with them. The case company hasn't had any problems with delivery times with its supplier.

Case D

Case company D is a manufacturer to produce cabins for tractors. The company purchases metals, glasses, tire products, coupling gears, steering wheels, lights etc. from China. Approximately 50 percent of purchasing comes from abroad and China's part of this is 17 percent. The company started first purchasing from China in 2004 through one European company who had relationships to Chinese suppliers. The company has found their own suppliers by visiting in fairs, and by using different contacts. Usually someone knows someone who could be a qualified supplier. Chinese business people have some much contact, so it is easier to search suppliers with the help of local people.

Price has been the main reason for purchasing from China. However, the company has not chosen the cheapest suppliers because they also require a good quality. The company is doing cooperation with every supplier. Changing the supplier usually takes from one to two years. It takes time and energy to develop long-term and trustworthy relationship with new supplier. This is the reason why the case company has chosen their suppliers very carefully in the first place. The company really wants to have long-term and close relationship with every supplier.

In general, the case company hasn't had any problems with its suppliers. The only problem was with one supplier who had financial problems and which led to its bankruptcy. In transportation, the case company uses DDU (delivered duty unpaid) Hampurg and DDU Mäntyluoto. This means that Chinese supplier pays all the costs until the product is delivered to the destination. The case company pays all the taxes and customs of the destination country. When the products are delivered, the company has a purchase inspection. If there are nonconformities in the product, next incoming delivery will go through different measurements.

The case company has four suppliers and three material controllers. They have production management system which is producing different kind of purchasing proposals. However, purchase orders are not transferred automatically to suppliers' database but the orders are being made manually. The company is doing the orders and Chinese suppliers do not have the access to the production management database. Cooperation with Chinese is different only because of the long distance. The process is the same as with Finnish or European suppliers. The company is just doing orders little bit earlier to China than to European suppliers. The company has two weeks stockpile for the products ordered from European countries and one month stockpile for Chinese products.

Communication happens mainly via email. The purchasing manager of the company travels regularly to China and spends two weeks there. The company is doing collaboration in R&D with its suppliers. It gives specific requirements for products and defines also customer's requirements. Chinese are designing products according to these guidelines and produces the final products for the case company. Planning work is done in Finland and designing in China. In the future the goal is to have closer relationship with suppliers. Both Finnish and especially Chinese respect to long-term relationship. The case company would like to have more cooperation in R&D and they are going to put a lot of effort on that.

The case company hasn't been any problems and the supply chain works between Finland and China the same way as with Finnish suppliers. The case company has been very satisfied to its suppliers. The suppliers were chosen very carefully and vendors' know-how is in excellent level. Chinese work moral is very high which has affected to the level of satisfaction. Chinese are also very committed and accurate. They really respect their customers and are willing to do more for satisfied customers. For Chinese, the most important issues are customer satisfaction and value adding. The case company prefers to choose all their suppliers from Asia, if the distances would be shorter. The case company has been very satisfied for the fluent supply chain, and they don't see any reason for changing anything crucial. One thing to approve would be the storage, because it is causing a lot of costs. The case company expects that suppliers should take more care of warehousing, and in that way they could share the costs of warehousing more effectively.

Case E

Case company E is a group company to provide individual components, semi-finished products, assemblies and demanding equipment in the machine building industry. The company has been sourcing components from China for about 20 years.

The company is searching potential suppliers from China. It has gone through around 500 of them around China. The company seeks for the Chinese through many ways such as fairs, internet, customers and Finnish intermediaries. The starting point is through its Chinese personnel and their friendship networks. The company used a principle of 'word of mouth' to find out the trustable supplier. Quality and price are absolutely the two important factors when seeking for the suppliers. The company pays attention to the quality standard of the suppliers using in order to evaluate the reasonable quality level of the supplier. Especially, the company would learn and evaluate the quality in the future based on the quality standard.

The company audited potential suppliers and ordered test series and model series. The company is negotiating with the Finnish customers about the types of products would being source from China and what are the customer needs. Then the case company takes care of sourcing and the quality of the items.

The company believes there is no problem in the communication as the company has many Chinese and Chinese speaking personnel. On the other hand, the company also has found also persons capable of speaking English in the sourcing process.

The case company highlights some differences from their intensive sourcing activities in China. First, the challenges have been related to the understanding of the specifications as Chinese technical standards are so different. It causes some problems to the company when explain these specifications to the Finnish customers. In the cases if the company is not able to test the quality of materials internally, it will utilize some intermediary organization such as VTT (Technical Research Centre of Finland) to make the test. The second problem is related to payment processes. The company is usually asked to pay in advance so that the Chinese suppliers are able to buy raw material and produce the product. Thirdly, the company notices that there are differences on the understanding of the importance of quality. The case company states that test product is ordered from Europe, it is considered as how the final product can be produced at the top level of the supplier. In some cases Chinese suppliers take the test products as a kind of the draft of the desired product. The case company has just thought that this supplier is not capable of producing what they want as the test products are bad. However, later on when the supplier finds out that the company really wants to order these, it was fully capable of producing what the company wants. On the other end, in some case the first products received are exactly as the quality requirements, but the Chinese supplier has started to think that also some other kind of quality is good as well. Thus, the supplier would use other type of steel when some specified materials are not available right now. The shortcuts have been made and then the quality of the products has not lasted for long in this cold environment of Finland. The case company believes that some Chinese suppliers do

not understand the importance of sustainable, continuous quality as the quality culture is not well developed. Although the quality level is progressing with high speed in China, the company still finds these opportunistic suppliers who want to make extra money in a short term by making shortcuts. It is the reason that the case company makes close audit on quality assurance on-site in China. It always audit the way of functioning in Chinese companies beforehand. If quality is evaluated sufficient, the company continues to follow closely the level of price development.

The case company expects the improvements in the sourcing from China should be focused on on-time delivery and continuous quality.

CROSS-CASE DISCUSSION

The case study illustrates the practices of Finnish companies in the sourcing process from China. The main tools to find out the potential suppliers are internet, personal contacts, and trade fairs. The case companies have used internet to find information of suppliers. Google is good way to find information and website www.alibaba.com where all the suppliers are listed. Visiting in Chinese fairs is a good way to find contacts and qualified suppliers. It is good to have a local contact because usually they have even more contacts. Chinese are respecting meeting face to face so it is also important, every now and then, to visit in China. The development of personal trust is highly important in China. Guanxi is highly emphasized in China and it means personal relations. Also deep trust is important for successful business relations in China. Regular visits to the country help to create a friendly and cooperative atmosphere, which in turn facilitates the exchange of information, the building of mutual trust and the efficient management of quality control and other supervisory activities. The tighter the links to Chinese partners, the more explicitly relations can be managed.

The orders are made via email. Because of the long distance, companies are usually preparing for longer delivery times and that's why they are doing the orders little bit earlier than the European orders. Email is the easiest way to communicate with suppliers. Chinese people usually write English better than speak it. Chinese suppliers are sending different reports and documents in different manufacturing phases and usually companies know when the suppliers are going to deliver the products. All the companies are doing orders manually, and supplier has not the access to company's database. Orders are not going to suppliers automatically. Logistics is usually handled through couriers or with suppliers. Supplier usually pays costs until the product is delivered to its destination. The buyer pays destination country's customs and taxes. Delivery times have been accurate in three interviewed companies but only one company has had problems with delivery times.

Quality is the central issue when sourcing from China. Purchase inspection happens both in Finland and in China. Some companies work closely to audit the quality of products on-site in China before the suppliers deliver the products to Finland. The other companies are doing the quality control when the products are delivered to Finland. After the inspection, products are delivered to the customers or they are moved to the production line. If a problem occurs, they

are being informed to the supplier, and compensations are going to be made. Only little reclamation is being made, because Chinese products have good quality and they are properly made.

Two of the five case companies are doing cooperation with suppliers in R&D at the current stage. In the future the two companies really expect to further development the R&D cooperation. The other companies may develop the cooperation with suppliers and expand it to R&D. Chinese know-how is in so high level that companies are outsourcing their design pleasingly to Chinese.

The main reasons to choose Chinese supplier are price, quality, know-how and also Chinese high working moral and their perseverance. Due to the increasing competition globally, the companies are subject to be more cost effective. Even though the logistics distances are long, purchasing from China is still cheaper than from the Europe. China also offers a large scale of suppliers when comparing to European countries. Price is tempting, but usually companies are not choosing the cheapest supplier. Quality and price are making a strong combination which is affecting mostly to the choosing of supplier. Good cooperation is also affecting to the satisfaction and continuous of collaboration.

In general, the case companies have been very satisfied to cooperation with Chinese suppliers and also to the fluency of the supply chain. Chinese were described as faithful, friendly, precise, efficient, competent, and organized and they really respect their customers. Besides the communication problem because of language barrier, the case companies illustrate the central problems of on-time delivery and sustainable quality control, especially the differences on the understanding of quality (e.g. case E).

The case study illustrates the practices of Finnish companies in the sourcing process from China. Figure 3 summarizes the stages and activities of the sourcing process.

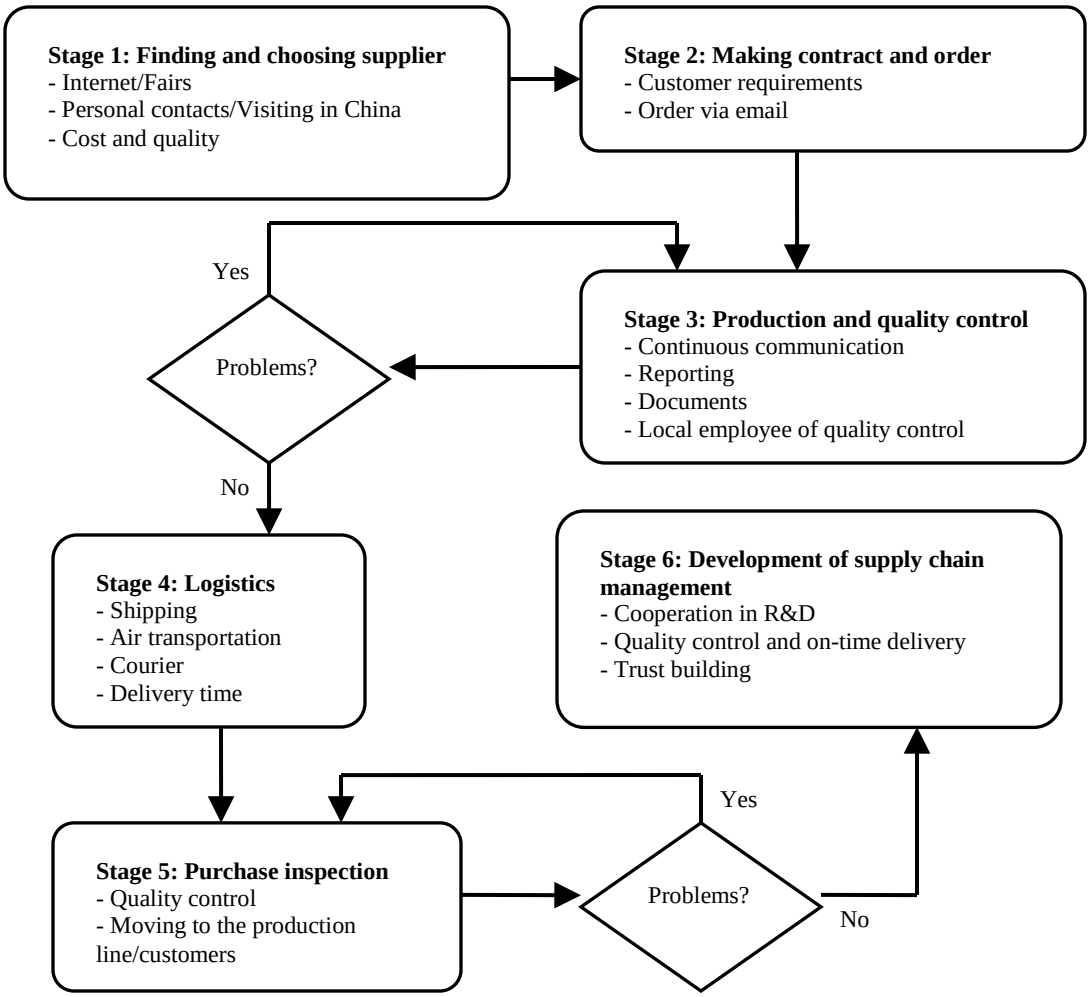

Figure 3: Sourcing process of Finnish companies in China.

CONCLUSIONS

The paper studies the sourcing process of supply chain management through learning the practices of Finnish companies sourcing from China. There are six stages of souring from China in the cases – finding and choosing suppliers; making contract and orders; production and quality control; logistics purchasing inspection and development of supply chain management. The Finnish case companies seek for the potential suppliers through internet, trade fairs, network and a local visiting. Cost and quality are the two main factors to select a qualified supplier. The communication with Chinese suppliers is mainly through email to exchange the quality specification and the information of orders. Quality control is the central issue in the sourcing process. The Finnish companies attempt many ways to guarantee the quality by checking the quality standards of the Chinese suppliers, asking the production report and documentation, and using a local employee for quality control. The problem in logistics focuses on the on-time delivery, although some companies have not suffered the problem of delayed delivery. The case companies make a double check when the products arrive in Finland. The

experiences of the case companies with Chinese suppliers are positive. Both the case companies and Chinese suppliers expect to establish a long-term cooperative relationship in the areas of R&D activities, quality control and on-time delivery. A framework of the sourcing process is developed in the paper (Figure 3).

Theoretically, the case study does not illustrate that the process of sourcing from China is quite different with the sourcing process from the other countries (e.g. Zeng 2003, Van Weele 2005). The major stages of sourcing process are similarity. Compare the study of Trowbridge (2006), the case study also does not reveal many activities on the preparation stage. One explanation can be the case companies already identified China as the sourcing destination. The other explanation is the organizational structure is simple as most of the case companies are SMEs. However, the case study highlights the core activity of sourcing from China is quality control. One more phase focuses on the quality control in the process of sourcing from China. Especially in case E, the company emphasizes there are differences on the understanding of sustainable quality between Finnish company and Chinese supplier. The difference can affect the supplier screening and quality control. The study generates managerial implications that sourcing from China is more or less a continuous process of quality supervision and improvement. In this sense, it is important that a long-term relationship with trustable supplier is built in the process of sourcing from China so that the companies can achieve cost advantage.

There are some methodology limitations in the research. First, all the case companies involved in the study show a very satisfactory sourcing experiences with the Chinese suppliers. From the methodology perspective, the five companies are successful cases. The failure cases are not available in the process of selecting case companies as they do not have any business relationship with Chinese suppliers. Therefore, the sourcing practices may not exhausted reveal all challenges in other situation. Secondly, the findings of the study mainly focus on the sourcing practices when the companies do not have own physical facilities in China. The research results may not be directly applied to the sourcing process of those companies with local production premises in China. For further study, it is worth to exploring the detail study on quality control with the Chinese suppliers. Furthermore, the research is supposed to highly improve the practices of sourcing from China when the companies expect to achieve cost competitiveness.

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SOURCING FROM CHINA – PERSPECTIVES FROM FINNISH SMES

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ABSTRACT

The aim of this study is to describe the experiences of Finnish SMEs (Small and Medium - sized Enterprises) sourcing from China. The study is made as part of CHISU -project (Building an internationalization process for Chinese markets) funded by European Regional Development Fund (ERDF). SMEs are expected to face challenges in international sourcing due to their limited resources and experience in the international business. Moreover, the Finnish SMEs are expected to face context-specific challenges due to their geographical and cultural distance to the market.

This case study seeks to find answers to the following research questions: What are the drivers for Finnish SMEs to start sourcing from China? What kinds of challenges were faced in sourcing from China? These research questions are answered through eight case studies in the Finnish SMEs in which sourcing from China plays a significant role.

As a result of this study, the main drivers and challenges related to the process were analysed and evaluated. SMEs analysed here faced special drivers and challenges related to sourcing from China – more drivers than challenges were pointed out. SMEs could strongly benefit from external support tailored for their context specific needs. The results of this analysis are mainly applicable to the SMEs in Finnish context.

Keywords: international sourcing, internationalization, small and medium sized enterprises, China

INTRODUCTION

This study is part of the CHISU project funded by European Regional Development Fund (ERDF). Economic growth has increased rapidly for many decades and China offers a lot of possibilities for both large and small companies. China is a world's fastest growing economy,

and its economy has grown already almost 30 years (Kettunen et al. 2008). China is the second largest economy in the world after the United States, and it accounts for 7.5 % of the world's total economic activity. This study focuses on sourcing from China. The intention is to support SMEs planning to start collaboration with Chinese suppliers. The focus is on Finnish SMEs.

Multinational corporations have become increasingly interested in Chinese market for goods and services. In China, western firms face a business environment that differs from their home market. However, these firms can to learn about this market and improve sourcing accordingly. International sourcing refers to the purchasing of materials, components, and finished products from foreign suppliers. It thrives from globalization, communication technology, and transport system development, as well as the reduction of international trade boundaries. (Carlsson et al. 2005) These issues have developed rapidly in the Chinese market within the recent history, making it one of the most attractive sourcing markets. Since most big retailers are now sourcing from China, smaller ones typically wonder whether they should do the same, but are often put off by the complexities of getting started. China is the third largest exporter in the world, so there are plenty of serious and high quality suppliers.

SMEs are considered to be an important and integral part of every country's economy, the fastest growing sector of many economies, more flexible and adaptable in terms of structure and having a faster speed of response than larger organizations. (Tagliavini et al., 2001). SMEs are often associated with a higher economic growth of nations (See i.e. Reynolds 1997, Robson & Bennett 2000). According to Beck et al. (2005) the share of SME employment in total manufacturing employment is associated with higher rates of gross domestic product (GDP) per capita growth. The existence of a large SME sector should rather be considered as one characteristic of successful economies. However, in a relatively recent study, Ayyagari et al. (2007) analysed the relationship between the relative size of the SME sector to total employment in manufacturing and GDP across 76 countries. By presenting comprehensive statistics utilising a cut-off of 250 employees, Ayyagari et al. (2007) show that on the average in these countries, SMEs' contribution to the labour force constitute 54% of the economy. The impact of SMEs on employment is significant. On the other hand, compared to large enterprises, SMEs typically have fewer financial resources, lower technical expertise, and more limited management skills (Blili & Raymond 1993). Therefore, it is increasingly important to study SME perspectives to Chinese market. Growth (See i.e. Muhos et al. 2010) is a critical issue for long-term survival of SMEs and development towards large scale companies and sourcing from China may provide opportunities for speeding up this complicated process.

The aim of this study is to learn from the companies that have experience on sourcing from China, and to provide practical guidelines for SMEs. This study may help SMEs to function more effectively and efficiently in Chinese market. More information is needed of how to source from China and what needs to be taken into account. Further, this study aims to clarify the management of sourcing process from Finnish SME's perspective. There are still a lot of complexities in international sourcing. For example long lead times, environmental uncertainty, lower levels of quality, extension of supply lines, delivery risk, cultural differences and sourcing professionals' lack of skills and capabilities are among the biggest

impediments in global sourcing. Sourcing from China may be important to a firm's competitive position as a means to access raw materials, improve quality, lower cost, or access technology.

The research questions of this study can be articulated as follows:

1. What are the drivers for Finnish SMEs to start sourcing from China?
2. What kind of challenges and advantages were faced in sourcing from China?

In this study, the case study was selected as a potential strategy to answer the main research questions. According to Yin (1989, p. 23) *'a case study is an empirical inquiry that: investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used.'* Eight case companies located in Northern Finland were interviewed and analysed.

This study consists of five parts. In the introduction the background, motivation, research problem and research questions are presented. In the second, theoretical part of this study, the short introduction to Chinese market, the sourcing perspective, and the most potential drivers and challenges related to sourcing are presented. Third the method of this study is described. Fourth, through description and analysis of eight case studies, the answers to the research questions are provided. Finally, in the discussion part the main results, limitations, and further research topics are covered.

SOURCING FROM CHINA – PERSPECTIVES

China is a world's fastest growing economy, and its economy has grown already almost 30 years (Kettunen et al. 2008). The economic growth started in early 1980s when China opened its markets and after that, many Western companies have been interested in Chinese markets. China is the third largest economy in the world after the United States and Japan, and it accounts for 7.5 % of the world's total economic activity. The Chinese market has grown very fast and it has affected its economy in many ways. The personal income levels have become higher in China, and the competition has grown. China finds it challenging to train and develop its human resources. Consumers are more demanding and they insist high quality products. Foreign investors have become more interested in China's market – usually expanding markets and low labour costs are the main factors why Western companies want to invest in China. Also Finnish companies have started to pay attention to Chinese markets and in 1990's the large companies moved to China, followed by SMEs in 2000's. China has maintained its position in sixth largest trade partner of Finland, and China is also Finland's largest trade partner in Asia.

Chinese market

China constitutes an important country for sourcing and in today's global economy China is increasingly seen as a key area for international sourcing. (Salmi 2006.) Finnish companies started to do business in China already in 1950's. Large companies started to move to China

gradually in 1980's, but big wave of investments happened in 1990's, when subcontractors and contract manufacturers were forced to follow their customers. SME's moved to China mainly in 2000's.

As China has opened up its economy to foreign investors, transnational corporations have become interested in China's enormous market for goods and services (Roy et al. 2001). China and its reforming markets have increasingly attracted the attention of Western companies, because of its expanding markets and low labour costs. China constitutes an important country for sourcing and in today's global economy China is increasingly seen as a key area for international sourcing. According to Nassimbeni & Sartor (2006), China's success does not only drive from its low labour cost. It is the result of strategic planning, the outcome of a logistic system that, if not perfect, is better by far than any other system existing in developing countries. China means strong internal competition, pride and the ambition to become the strongest economy in the world. (Salmi 2006.) However, it must be remembered, that unforeseen events, surprises, risks and delays are possible. The lure of enormous markets and profits in China comes entangled with sources of risks and uncertainties.

To succeed in China, a Chinese partner plays a key role. Specifically, foreign firms making their initial entry into China's market have found it almost impossible to succeed without a Chinese partner. (Wong & Maher 1997.) Guanxi is a key concept for understanding social behaviour in China, especially the linkage between interpersonal relations and the attainment of desirable resources, and entails a strong social obligation to do favours for another person. The development of personal trust is highly important in China. (Björkman & Kock 1995.) Business environment in China is differs from environment of Western firms and creates different challenges. One way to learn about Chinese markets is to be present in China and acquire knowledge of the Chinese market. There are two different ways to manage cultural distance; either the company uses a trustworthy partner familiar with Chinese business culture (intermediaries, an agent) or the company itself invests in building and nurturing long-term business relations. The way for Western companies to ensure and increase commitment from the Chinese side is to build up personal relations. Personal relations are also important for overcoming barriers in communication.

Sourcing perspectives

Managing the sourcing task in the supply chain is a challenge many corporations (Karpak et al. 2001). In an increasingly competitive business world, global competition puts high demand on the flexibility of industrial companies. As a result of worldwide competition, firms are combining domestic and international sourcing as a means of achieving a sustainable competitive advantage. Organizations have realized that a world-class global supply base is required in order to meet world-class competition. The catalyst for global sourcing has been the worldwide competitive pressure forcing firms to reduce costs and to improve quality and responsiveness. (Gelderman & Semeijn 2006.) The need to gain a global competitive edge on the supply side has increased substantially. Particularly for companies who spend a high percentage of their sales revenue on parts and material supplies, and whose material costs represent a larger portion of total costs, savings from supplies are of particular importance. Moreover, the emphasis on quality and timely delivery in today's

globally competitive marketplace adds a new level of complexity to outsourcing and supplier selection decisions. Many companies attempt to streamline the number of suppliers from which they source. (Karpak et al. 2001.) Purchasing is the key intermediary between members of the supply chain. It is essential that purchasing serve an integral, if not a primary role, in the management of the supply chain. (Carr & Smeltzer 1999.)

Quintens et al. (2006), conceptualized the sourcing process, and defined four phases: (1) the investigation of purchase markets and the screening of potential suppliers, (2) the selection of supplies, (3) the negotiation and contraction, and (4) supplier evaluation and follow-up. Coordination of purchasing encompasses the creation of synergies from economies of scale, scope, process, and learning.

Companies have changed their focus from short term transactional sourcing concept to supply chain management approach where they concentrated on developing long-term relations with suppliers including forming partnerships that resulted in improved coordination of supplier networks (Karpak et al. 2001). Supplier relationships connect the company's internal configuration of supply to the external resources of its suppliers. Therefore, interaction in relationships and, for instance, the skills of the interacting personnel come to play a critical role in ensuring efficient supply. Indeed, attention on the supply side has shifted from product features to external issues: supply management increasingly stresses, for example, a process focus and a market focus. (Salmi 2006.)

The drivers for international (or global) sourcing can be, for example, decreasing tariffs, improving transportation, communications and information technology, globalization of products, services and markets, global competition, and economic regionalism (See i.e. Pennanen et al. 2011). International competition has increased and now the services and products are available worldwide. Firms have to offer greater product and service quality at lower cost in order to remain competitive. Moreover, companies need to work more closely with its suppliers and customers.

In international sourcing, buyer–supplier relationships take time to establish. During this process, a key issue firms must address is effective management of the supplier network, including identification of supplier selection criteria, supplier selection decisions, and monitoring of supplier performance. Supplier selection decisions determine the number and identity of vendors that should be selected as supply sources and how order quantities should be allocated among the selected vendors. Vendor selection is inherently a complex decision. The decision process involves more than one criterion, products have many attributes such as price, quality, service, and more, and members of sourcing committees bring diverse criteria to sourcing decisions that are driven by their departmental interests such as cost, reliability, and delivery. These factors are affecting to the selection complexity (See Karpak et al. 2001)

Potential challenges in global sourcing have been mentioned by several authors (See i.e. Mentzer 2001, Fredriksson & Jonsson 2009, Salmi 2006):

Table 1: Potential challenges in sourcing from China.

Internal challenges	External challenges
- Weak international sourcing skills and capability - Lack of international sourcing management skills and capability - Lack of international sourcing strategy - Lack of information technology fit for international sourcing - Language skills and capabilities - Cultural skills and capabilities	- Extended supply chain and long lead times - Uncertainty of business environment and unpredictable inflation and exchange rates - High levels of government intervention - Quality challenges and delivery challenges - Geographic distance and different time zone - High logistics and transaction costs - Cultural distance

As presented in the Table 1, there are many complexities in global sourcing. Long lead times, extension of supply chain, environmental uncertainty, lower levels of quality, delivery risk, cultural differences and sourcing professionals' lack of skills and capabilities required to manage globally are among the biggest impediments in global sourcing. Global sourcing may be important to a firm's competitive position as a means to access raw materials, improve quality, lower cost, or access technology. Pursuing a global procurement strategy successfully requires that a firm possess a supply chain orientation and the skills to deal with the complexities and uncertainties of the global environment.

THE METHOD

This is a multiple case study with holistic strategy. The case study followed the process presented in figure 1:

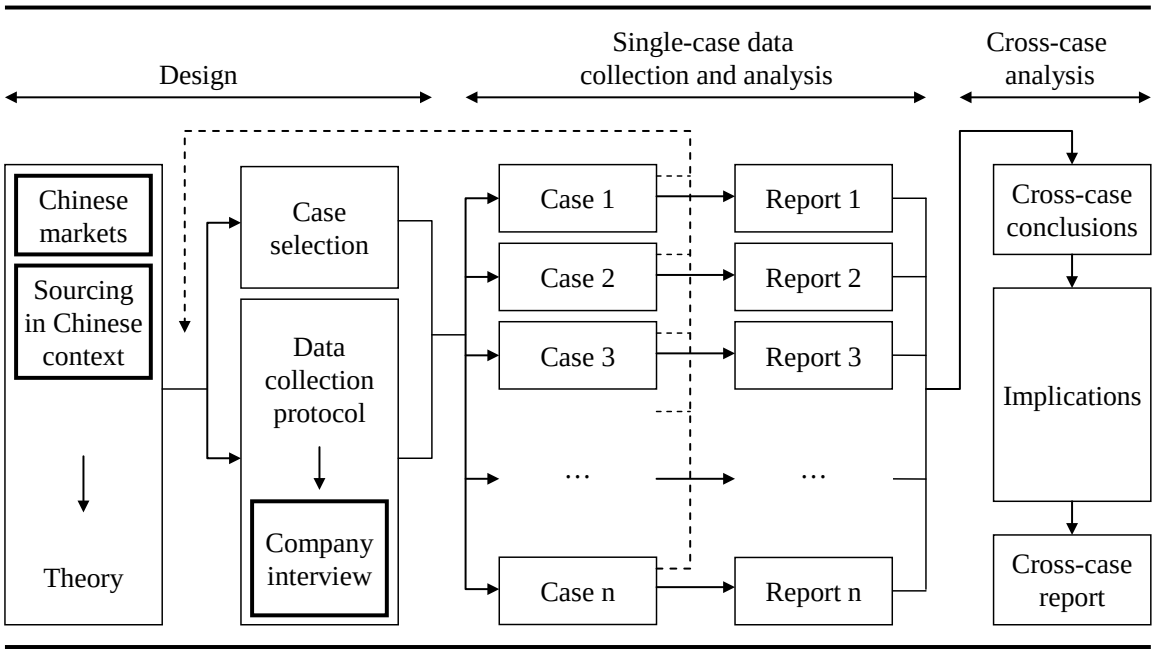

Figure 1: The research process (Modified from Yin 1989).

The unit of analysis in this study is the SMEs with experience on sourcing from China. The definition of an SME is different in different contexts. The US context, for example, offers many definitions of SME depending on the industry. For example, in some industries, SME is a company having less than 500 employees. In the European context, the SME is a company having less than 250 employees. This difference on definitions needs to be taken into account when studying the SME related literature. The variance in defining the SME causes some confusion in the field of SME research. Ayyagari et al. (2007) covers this topic in his globally focused, statistical study on SMEs (p. 416): *The term SME covers a wide range of definitions and measures, varying from country to country and varying between sources reporting SME statistics. Some of the commonly used criteria are the number of employees, total net assets, sales, and investment level. However, the most common basis for definition is employment, and here again, there is variation in defining the upper and lower size limit of an SME. Despite this variance a large number of sources define an SME to have a cut-off of 250 employees.* (Ayyagari et al. 2007). Because of the case context, the European definition is utilised. Within the SME category, the European Union defines medium sized firms as having 50-249 employees, small firms as having 10-49 employees, and micro-firms as having 0-9 employees. (Storey 2003).

The case study evidence was collected by two graduate students as part of their Master's Theses (See Karjalainen et al. 2010, Pennanen et al. 2010) in the first and the second quarters of 2010. The Theses were conducted using similar research process and questionnaires. The case study evidence is further analysed synthesized through this analysis.

THE CASE STUDIES – PERSPECTIVES FROM FINNISH SMES

The case study was carried out in eight SMEs located in Northern Finland. The basic information of the case companies is presented in the following table:

Table 2: The case companies – basic information.

Case	SME category	Industry	Sales (year 2009)
A	Small company	Business-to-business wholesale trade	10 million €
B	Medium-sized company	Mechanical industry – steel and aluminium products	35 million €
C	Medium-sized company	Wholesale trade and import of non-eatable products	50 million €
D	Small company	Manufacturing of metal products	2 million €
E	Small company	Custom made training and racing clothes	3 million €
F	Medium-sized company	Injection moulding and mould manufacturing	15 million €
G	Micro company	Contract manufacturing and design for high-end technology leaders	30 thousand €
H	Medium-sized company	Manufacturing of safety cabins	55 million €

Case A started sourcing from China in early 1990's. The main focus is on sourcing of bearings which are the main product of the company. In the beginning, the drivers for starting sourcing from china were pressure to lower prices, lowered product origin sensitivity among customers, willingness to respond to customer needs, and open-mindedness of the company. The advantages of the Chinese market have been low costs of products, low labour cost, fast response, fast delivery, sufficient quality, customer service attitude, resources available for product development, and location near to customers who have also moved functions to China. Based on the experiences of the company A, some challenges were faced. Among these challenges were some quality problems, long physical distance and different time zone.

Case B started sourcing from China in 2007. The main focus is on sourcing of steel products, components and plastic products. The main drivers for starting sourcing from China were low costs of products, tools, labour, and raw material, high prises of domestic suppliers, typically fast response to orders, and positive earlier China experiences of managers. Based on the experiences of company B, there were a couple of challenges related to sourcing. Among the challenges were quality challenges, long delivery times, problems in delivery management, grown inventories, constricted communication interface. It has been a significant challenge that Chinese supplier have not been willing to shorten delivery time.

Case C started sourcing from China already in 1960's. First experiences were related to Hong Kong and then the sourcing was extended to the mainland China. The main focus has been all the way sourcing of wholesale products. The main drivers for starting sourcing from China were low cost of the product, sufficient quality, competitive price-quality ratio, and sufficient logistics (compared to some other countries). Based on the experiences of company C, there were a couple of challenges related to sourcing. Among these challenges were unexpected government intervention (tax refund restriction), bureaucracy in Finland and EU (i.e. protectionist taxes), sudden closure of supplier, IPR-problems, agreement problems, and language barrier.

Case D started sourcing from China in 2001. The main focus is sourcing of specific hard metal products. The main drivers for starting sourcing from china were managers strong experience on international sourcing, manager's strong experience on selection of product sourced, favourable exchange rates, low cost of raw material, low cost of product, low cost of tools, availability of raw material, sufficient quality of product, fast delivery, improved reliability of delivery, flexibility in tailored products, and good motivation for collaboration. Based on the experiences of company C, there were a couple of challenges related to sourcing. Among these challenges were risk of becoming short-changed, risk of bypassing in supply chain, extra resources tied to quality control, and complicated methods of payment.

Case E started sourcing from China in 2004. The main focus is the sourcing of customised training and racing clothes. The main drivers for starting sourcing from china were raising costs of earlier suppliers, good connections of owner to Chinese suppliers, low labour cost, low material cost, availability of material, and good industry specific knowledge of Chinese supplier. Based on the experiences of company E, there were a couple of challenges related to sourcing. Among these challenges were problems in keeping promises, extra resources tied to quality control, quality problems, poor delivery reliability, and long delivery time.

Case F started sourcing from China mainly in 1990's. The main focus is the outsourcing of moulds. However, also other types of sourcing, such as sourcing of raw materials is needed. The main drivers for starting sourcing from china were need to respond to increasing price competition, competitors sourcing from China, need to increase volumes, lack of suppliers in other countries, delivery reliability, precise culture, Chinese high morale in working, and high-level technology knowledge and potential resources for product development. Based on the experiences of company F, there were a couple of challenges related to sourcing. Among these challenges were long physical distance, variable costs of logistics, and constricted communication interface.

Case G started sourcing from China soon after establishment (year 2004). The main focus of the case G is on sourcing of electrical semi-products, cables, parts, and connectors. The main drivers for starting sourcing from china were manager's earlier experience in business with Chinese companies, sufficient quality, low price of the product, Chinese active way of working and very rapid response in communication. Based on the experiences of company G, there were some challenges related to sourcing. Among these challenges were poor English language skills in China and culture-related communication challenges especially situations where advice is needed.

Case H started sourcing from China in 2004. The focus is on sourcing of metals, glasses, tire products, coupling gears, steering wheels, lights etc. The main drivers for starting sourcing from china were low price of the product, quality of operations, high work moral of Chinese people, high commitment, excellent level technical know-how, respect towards customers, and accuracy. Based on the experiences of company G, there were some challenges related to sourcing. Among these challenges were time consuming trust and relationship building, sudden closure of supplier (and loss of moulds), long physical distance and costs of grown inventories.

On one hand, the case companies had many drivers for starting sourcing from China and keeping that option also in the longer run. The main drivers towards sourcing from China are presented in the following table 3:

Table 3: Drivers for sourcing from China.

Internal drivers (Cases)	External drivers (Cases)
- Willingness to respond to customer needs (A)	- Low costs of product (A, B, C, G, H)
- Open-mindedness of the company (A)	- Low labour costs (A, B)
- Lowered sensitivity to product origin (A)	- Production near to customers (A)
- Positive China-experiences of managers (B, G)	- Fast delivery (A, D)
- Managers strong experience on international sourcing (D)	- Fast response in communication (A, B, G)
- Manager's strong experience on selection of product sourced (D)	- Sufficient quality (A, C, D, G)
- Need to increase volumes (F)	- Customer service attitude/motivation (A, D, G, H)
	- Resources for product development (A, F)
	- Low cost of tools (B, D)
	- Low raw material cost (B, D)

	- High-cost domestic suppliers (B) - Price-quality ratio (C) - Sufficient logistics (C) - Favourable exchange rates (D) - Availability of raw material (D) - Improved reliability of delivery (D) - Flexibility in tailored products (D) - Increasing price competition (F) - Competitors sourcing from China (F) - Lack of suppliers in other countries (F) - Delivery reliability (F) - Precise culture (F, H) - Chinese high morale in working (F, G, H) - High-level technology knowledge (F, H) - Quality of operations (H) - High commitment of Chinese suppliers (H)

On the other hand, many challenges and complexities were faced. The challenges faced in sourcing from China are presented in the following table 4:

Table 4: Challenges faced when sourcing from China.

Internal challenges (Cases)	External challenges (Cases)
- Problems in delivery management (B) - Grown inventories (B, H) - Extra resources tied to quality control (D)	- Quality problems (A, B, E) - Long physical distance (A, F, H) - Different time zone (A) - Long delivery time (B, E) - Constricted communication interface (B, F) - Unexpected government intervention (C) - Bureaucracy in Finland and EU (C) - Unexpected closure of supplier (C, H) - IPR-problems (C) - Agreement problems (C) - Language barrier (C) - Risk of becoming short-changed (D) - Risk of bypassing in supply chain (D) - Complicated methods of payment (D) - Problems in keeping promises (E) - Extra resources tied to quality control (E) - Poor delivery reliability (E) - Changing costs of logistics (F) - Cultural distance (G) - Communication problems (G) - Time consuming trust and relationship building (H)

As a conclusion of the empirical part, it can be said that Finnish SMEs faced both strong drivers for sourcing from China as well as many challenges on the way to build successful supply chain from Chinese market to Finland.

DISCUSSION

The aim of this study was to describe the experiences of Finnish SMEs sourcing from China. Eight cases located in northern Finland were studied in order to point out the common drivers towards sourcing as well as the common headaches. As a result of this study, the main drivers and challenges related to the process were analysed and evaluated. The answers to the research questions 1 and 2 can be condensed into a table of common drivers and challenges:

Table 5: The drivers and challenges in Finnish SMEs sourcing from China.

The main drivers	Cases	The main challenges	Cases
Low costs of product	5	Quality problems	3
Sufficient quality	4	Long physical distance	3
Respect of customers	4	Long delivery time	2
High work morale	3	Poor communication interface	2
Fast response in communication	3	Unexpected closure of supplier	2
Fast delivery	2	Grown inventories	2
Precise culture	2		
Low cost of tools	2		
Low labour costs	2		
Low raw material cost	2		
Positive experience of managers	2		
Product development resource	2		
High technology knowledge	2		

The managers of the Finnish SMEs recognised more drivers than challenges as they described their approach to the establishment of a sourcing channel between China and Finland.

The clearly most common group of drivers was related to low costs. Not only the low costs of a product sourced but also the labour-, tool- and raw material costs. Sufficient quality played an important role as well – without a sufficient quality of products the investment would not have paid for itself. It should be noted that sufficient quality meant different things for different cases – however, no one of the companies seemed to be willing to pay for 'over-quality'. Respect for customers and high work morale were important drivers as well and were backed up with the earlier positive experiences of managers in some cases. Fast response and fast delivery times were pointed out by some of the managers – these drivers seemed to fit with the precise culture mentioned in two cases. Finally, the high technological know-how of Chinese suppliers was found a positive driver – this notion was supported with the notion that two managers saw a Chinese supplier as an important resource for product development collaboration.

A couple of challenges were noted in more than one of the cases. Quality problems were noted as an important challenge – this notion was supported with the notion of extra resources tied to quality control. This seems to conflict with the 'sufficient quality' -driver. Long physical distance was seen as an important challenge as well – partly because of the fact that some cases suffered longer than expected delivery times. This led in some companies to overgrown inventories and extra costs. Two companies faced unexpected closure of a supplier, which practically meant the loss of resources invested in these suppliers. Finally, the communication interface between partners was seen as poor and constricted by technological or human barriers.

This analysis may support for the managers of Finnish SMEs considering sourcing from China in their critical decision. The viewpoints pointed out by the managers with experience on sourcing may shed light to the factors that need to be taken into account prior the decision and during the development of a sourcing process between China and Finland. The results of this analysis represent the viewpoint of SME functioning with fewer financial resources, lower technical expertise, and more limited management skills – this viewpoint is often different from a viewpoint of large enterprises.

This analysis is based on a limited number of cases. A construct validity of the study is based on a research plan that has worked as a road map through the study. The case study used multiple sources of evidence. The synergy between quantitative and qualitative data was used. The chain of evidence was preliminarily defined in a research plan to strengthen construct validity. The internal validity of the study relies on the research design. In theoretical part, the theoretical background was presented and in empirical part the data was shown to enable analysis. The test of external validity shows that the findings of the study cannot be widely generalised because of the uniqueness of the cases. The research findings depend on the point in time when data is collected. Evaluation of the reliability highlights the following points. Reproducing the same case study in the same environment later would change some of the findings. A case itself has a significant role when the case study research method is used. In addition, researchers' own paradigm or point of view inevitably affects the findings.

In the future studies it would be interesting to open more cases with more similar industrial backgrounds. The SMEs analysed differed from each other in many ways which weakens the applicability of the results. It would be interesting to compare the results of similar analysis made in SMEs located in other European countries or in US. The role of intermediaries in the support of SMEs in this challenging area requires closer look.

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D2 – Organizational-management perspectives

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CONCEPTULIZING ERP APPLICATION FOR SOCCER INDUSTRY

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ABSTRACT

The purpose of this conceptual research paper is primarily to investigate the opportunities in restructuring in entertainment industry with the focus on soccer clubs. The reason is the rapid advances in operational units and project management of restructuring processes, the new technology integration in new economy, e-business, which has no barrier in ERP application. A clear example of this development is Football Club (FC) Manchester United (MU) in soccer industry.

While soccer clubs (e.g. Real Madrid, Barcelona, Manchester United) appear to be simple enterprises, the complexity of their organizational processes provide opportunities in optimization through benchmarking with ERP applications in service industry.

From the literature, we learnt that a number of business processes at professional soccer clubs are compatible with the business processes at service industry. This has been the basis for a conceptual study on application of ERP (enterprise resource planning) business processes.

Keywords: Conceptualization, ERP Applications, Business Processes, Soccer Industry, Restructuring.

LITERATURE REVIEW

The literature study shows that English premiership clubs have been trying to understand the business processes for some time. In fact this is the area that we address as peculiar and different to any other ongoing research studies in ERP implementation at various organisations. From literature it does not appear to be a comprehensive research study in logistics of soccer clubs.

The current emphasis in pursuing success lies on the possession of top talents and trainer(s) in the team. Of course, there are some exceptions. A successful team can exist without a successful financial position. For example, Rayo Vallecano and Alaves in Spanish leagues moved from the 2nd division to UEFA Cup finals in late 90s. This paper investigates for factors other than financial position and consequently the presence of the top players in a team that can also contribute significantly to the success of a major soccer club in international leagues.
Davies (1995) used England and Wales Football premier leagues dataset on season-by-season team performance and gate revenue for the period between the 1946-7 and 1993-4 seasons. He concluded that; the use of revenue data offers two advantages over attendance.

First of all, there is an easier access to financial resources which grant clubs to attract better players so as to improve performance, and then revenue is a more appropriate measure of financial strength than attendance.

From the point of view of managing any organization it is important to establish the relationship between the inputs used in production and their relative contributions to output.
Sports' teams are similar to other enterprises in this respect attempting to provide a 'product', referring to a victory, by employing and combining various inputs (i.e. the skills and various team competencies).

A production function can serve as a basis to determine players' salaries, as well as helping to identify those areas in which a team's opportunities for improvement lie, including the type of player that should be acquired to strengthen and improve the team and similarly the current players that need to be shed. All these sports' team decisions are made, albeit informally, in the context of a production function.
The context of production function is practiced in the form of OPTA index in the English premiership football. This index breaks down the performance of the team to the performance of individual players.
Statistical tools in evaluation of the players and predictions of team success played a major role in previous research studies on team success and team performance.
OPTA Index is the matches' observations data in ball-oriented system on shots at goals, passes, tackles and clearances, dribbles and runs with the ball & free-kicks awarded, it provides extensive data for statistical analysis generating production function models and coaching efficiency models (Thomas, 2000).

Club Performance, Revenues and Economic Results

The evidence for the relationship between sports performance and revenue appear clear in English football (Barajas, A, 2005). For the economic results, it is worth observing the effect of sports performance on revenues and the relationship of these revenues with costs. Although both turnover and expenses depend on managerial skills, the expenses are more easily controlled than turnover because income relates to the consumer demand.

Deloitte and Touche (1999) carry out analogous studies comparing, by means of a non linear regression, the total incomes of Spanish football clubs in the first division with their ranking at the end of league championships in seasons 1996/1997, 97/98, and 98/99. In Scottish Premier League the relationship between economic results and sports performance is less direct and more complex than we might expect. In analysis of relegation, Deloitte and Touche suggests that the levels of attendance and states, without a solid base, that in the season which follows relegation fans continue to attend matches through force of habit.

Pricing, Habitual Attendance, and Revenues

Spenner and Fenn (2004) applied the model of Becker et al. (1994) to National Football League and found that the sports league is a habit forming product. Conceptually, fan loyalty may create habitual behaviour, leading to a dynamic model specification of attendance demand (Won, D.C., 2008). Using the two-period model, Ahn and Lee (2007) showed that inelastic pricing is consistent with team owners' profit maximization decision if attending sports games is habit-forming and if the inter-temporal elasticity of substitution (IES) in the attendance at sports games is small. Using both linear and non linear models with respect to the infinite horizon, Won and Young (2008) derived a stationary attendance level and price, as well as the paths of optimal prices and attendance preceding the stationary point. Then they compared these results with those of a static model that assumes the absence of habit formation.

Our theoretical finding and simulation results imply that; i) inelastic pricing is consistent with lifetime profit maximization (the confirmation of Ahn and Lee, 2007); ii) in the presence of attendance habit formation, both the long run equilibrium price and the level of attendance are greater than the corresponding static profit maximizing price and attendance; iii) the dynamic equilibrium paths indicate that a team owner lowers price during early periods, to induce greater present and future attendance; and raises it in the long run to take advantage of habit persistence in attendance; and (iv) while the dynamic price path for the case of strong habit formation begins below that for weak or absent habit formation, it increases rapidly and eventually terminates in a higher price.

Team Success Based on Players' Income

The economics of English league soccer bear some resemblance to the economics of the team sports in U.S. In other words, the method of analysis can be benchmarked for similar sports in the same industry. In a survey established for 39 premiership clubs, a performance and club wage bill (1978-1993) indicate that players earn wages that reflect their talents, and club expenditure on players is a fairly reliable indicator of talent and club performance, i.e. average league rank as a team in the premiership.

Assuming the players' income factor is constant; the same study shows that major clubs with a higher number of black players have a higher ranking Premiership league (Szymansky, 2000).

Production function models estimate aggregate team performance or the success over a season in the English premiership league.

The relation between team performance & revenue was investigated using co-integration & causality tests. The selection criterion for the test was the unbroken league membership between 1946 and 1994 (Dobson, 1998).

The dependence of performance on revenue seems to be greater for the smaller clubs than for the larger clubs. The empirical results support the fact that team success is concentrated for rather wealthy clubs at premiership leagues in England.

The revenue as a full context does not represent the successful performance of a club. The length of the club life time in business is part of the selection criteria for the test.

The influence of the lagged revenue on current performance is greater than the influence of lagged performance on current revenue (Audas, 1994).

The cost breakdown by a major Scottish premiership club shows approx 70% on players' salaries and that of staff and 30% on any other overhead expenses.

The data show the importance of revenues from media rights, sponsors, tickets as well as the contemporary changes in soccer business with the important role of management team, supply chain and commercialization process (Cain, 1987/2000).

A major sponsor, Vodafone, financed approx. 6% of the total Manchester United market value (GBP 500 millions) on the London stock exchange over four years while Orange financed the Formula I team for double the amount over three years.

Tottenham Hotspur was the first major club to float in the stock market in 1983 followed by Manchester United in 1991 (Szymanski, 2000).

Real Madrid with a market value of GBP 105.2 millions, second after Manchester United, and indebted for over US $ 110 millions, spent US $ 60 millions to buy Luis Figo from FC Barcelona in 2000.

On the basis of Manchester United Business characteristics as an entity, some dependent measurable indicators in club success can be drawn as; Revenues, Profits, Number of fans, Franchising capacities and Sponsorship.

For other sports in U.S. in particular, there are studies on production function, performance evaluation, and correlation analysis.

Similar studies took place on the performance evaluation, production function and coaching efficiency of the top teams at English premiership league.

In a study performed by the University of Chicago a logarithmic chart of average league ranks versus wage expenditure relative to average (logarithm) showed a direct relation between the players' incomes and the ranking of the soccer club in the English Premiership leagues.

In the English premiership, the injuries cost the clubs GBP 40 millions while statistics showed 10% of a club's squad were unable to play at any time. This figure indicated what a club would require to compensate from its allocated budget.

Under the new EC legislation, players' wages will rocket as clubs use the money they would have spent on transfer fees to induce players to stay, wages increased by 30% a season in the

UK and wage packets of GBP 100000 a week were inevitable, say football analysts at Deloitte & Touche.

Any club at the top of the premiership league is paying two third of their turnover in total wages.
The managerial efficiency scores were used as covariate in an estimated managers' survival function in which the duration of survival was found to be positively related to managerial efficiency.

One element of team performance that was completely beyond the soccer managerial control is the quality of the playing squad that could be inherited at the start of his spell.

To control for that element, the difference between the team's current league position and its initial position when the manager first took charge is included as a covariate in the hazard function.

With this formulation, the quality of squad inherited was reflected in the initial league position, and the manager was assumed to take either full credit or blame for any subsequent positional improvement or deterioration.

Possible criticisms for this formulation is the fact that;
First if the outgoing manager is underperforming at the time of termination, the initial league position may undervalue the strength of the playing squad inherited by the incoming manager. The latter, however, still faces the task and (if successful) takes the credit for reorganising and restoring confidence or motivation to a squad that was previously underachieving.

Furthermore, formulation does not control for the extent to which different manager could have access to funds to spend on players' wages and in the transfer market, other than those generated internally through the impact of team performance on gate revenues.
The manager's ability to control match and league outcomes is surely constrained by chronic unpredictability surrounding; fitness, performance and interactions of the players.

The process that determines the team productivity is opaque while results are transparent.
Each match is a zero-sum game and the results are ranking in the league. Promotions and relegations between divisions also create substantial and lasting rewards and penalties for success and failure, respectively.

For each club as a firm, the typical consequences of inadequate performance are not the loss of customers, internal reorganization, liquidation, or acquisition by competitors. All clubs retain a base of highly regular spectators.

Constraints to Restructuring Soccer Clubs

The rigid technology associated with the soccer club's main product tends to impose similar uniformity upon the club's organization and structure.

Despite what is generally perceived to be a very high and price inelastic demand for the services of professional football teams, the clubs themselves seldom make money.

Modelling team Success and Club Success in Professional Soccer

The team strength scores are used as covariate in an estimated team success function, wherein the team success is proved to be positively related to management quality.

Causal empiricism suggest that a run of poor results over a relatively short period within a season can have a far more damaging impact on the manager's survival prospects than would be suggested by its full season win ratio or efficiency score.

Organizational Performance & Managerial Turnover period 1972-1997 (Audas, 1999)

Short term fluctuations in performance strongly influence the involuntary termination hazard.

The latter is also heavily dependent on the team's current league position relative to its position when the manager took charge, and on the win ratio over the entire pull.

The match-level data set allows identifying the link between very short term fluctuations in team performance and managerial survival.

The effect of a change of manager on organizational performance is a well-researched topic, despite constraints on availability of suitable data and the difficulties encountered in defining unambiguous measure of inputs and outputs.

In this context, Lieberson & O'Connor (1972) established a prototype for much subsequent work on managerial succession effects, by investigating the links between changes of chief executive officer and subsequent movements in performance indicators, such as sales profits.

CONCEPTUAL MODEL

We define two types of success defined in this conceptual study; successful soccer club and successful soccer team. Although these two types of successes are interrelated, in modern soccer they are recognized from each other in terms of business and sport. A successful soccer club can provide the grounds for a successful soccer team. The club has to be primarily financially successful as an entity. This criterion of financial strength, or capability, is almost a prerequisite to the formation of a successful team. This criterion brings the operation management, structure and logistics of processes in a major soccer club in picture.

For example, Real Madrid makes a distinguished exception in this regard. FC Real Madrid as the most indebted soccer club of the world in late 90s, was financially supported by other institutes rather than successfully running a profitable business. The same situation applied to FC Valencia and other soccer clubs in Spain. Later, Real Madrid as an entity with a high debt to equity ratio succeeded in generating substantial revenues from national and international leagues.

We built two constructions for the two independent hypotheses and one integrated hypothesis; Team Success & Club Success, and Management Quality.

The independent measurable indicators from these two constructions are listed in the scenarios I to IV.

The medical team (i.e. selected by the management team as support and advising staff), the audience (fans), the season (weather), sponsors (e.g. their financial contribution), culture (e.g. measured with the fans) and the environment (e.g. the pitch, fans and the weather) are among the dependent indicators.

The purchase of famous players and trainers by clubs counts also as a form of publicity. The source and size of revenues of a club are related to the success of its team (e.g. in a national and champion leagues). This is generated in principle from the public media, ticket sales and the sale of the players.

The model consists of the management team professional knowledge described as technical director, coach (his history and his references) and president director (e.g. business network, supply chain, procurement skills, and etc). And the proposed model represents the management of a typical major successful club in Europe.
The barometers in management quality, players' talent and degree of success of a soccer club (e.g. ranking in national and international leagues) will be indicated using a scale of 1 - 10.

Club Success = f (number of participations in the international leagues over the period of five years, e.g. Manchester United, financial position of the club and its value ranking in the entertainment industry, e.g. Manchester United is ranked as number one in generating revenues.)

Management Quality = f (technical director (e.g. full time years in physiology with a no. of years' experience in other professional clubs, trainer (e.g. cooperation with technical director and an international proof record of success in coaching, president (e.g. negotiations skills with network capacities)

Team Success = ƒ (sum of the quality individual players, no. of years of service with professional leagues on the same position, top 10 % and bottom 10 % of the national leagues)

Team Strength = ƒ (no. of core players over the three years period, no. of top talent players with transfer fees above GBP 20 million, No. of injuries over the period of three years, No. of the coaches over the three years period, no. of nationalities over the three years period)

In order to design the score models for the two constructs, the indicators are given values (weight factor), i.e. one to ten score models.

Team Success Based on Coaching Quality

We take the coach/players and situations/games as two opposite poles wherein these two poles have to get together in order to make a successful team.

Thus training situations should be as close as the actual game situations. Equally the understanding and the relation between the coach and the players should be as close to each other as possible.

Most literatures showed that major focus of both research and commercial efforts were on players' income as the team key success factor.

The club success is directly related to possession of top players in the team, in which the players' talents are rewarded with their incomes.

The impact of players' talents, players' salaries and the coaching performance in team success and its ranking is empirically correlated in various literatures.

The emphasis of this conceptual study is on the operation of management team and related business processes in a major soccer club. The purpose is to find the optimal operation for a major soccer club to boost its performance as an entity and as a team in national and international leagues.

The models derived in this study suggest that both team success and club success as independent constructs are related to the management quality.

For the measurement of management quality, we can suggest that the index is weighted equally by three decision making organs; president, technical director, and the soccer coach.

Each organ has a 30% share in the success and failure of the team and/or club success.
The independent variables in this model of team success are related to players' performance in this model.

Club & Team Success Performance Concept;

Regression Analysis

Club Success:
Revenue of clubs, γ; Wages, χ

Team Success:
Club Ratings, γ; Management Quality, χ

This study proposes a methodology based on regression analysis of the independent variables against dependent variables.

The measurement of management quality can be related to the dollar value of the coach in the market. Then a correlation coefficient for regression lines can be drawn.

Hypotheses

Hypothesis 1

Team Success

The management team is defined by the management team (technical director + coach and the president) of the soccer club.

The hypothesis of team success is evidenced by a higher proportion of the variation in league performance which is attributed to the management quality and team strength.

Team success is characterised by ranking at national and international leagues which is directly dependent on the team strength. Team strength is in turn based on measurable indicators on players' talents and team formation.

The combination of the two elements can result in successful and unsuccessful scenarios in the following forms;

Successful Team

- Moderate team strength and high management quality
- High team strength and high management quality
- High team strength and low management quality

Unsuccessful Team

- Moderate team strength and low management quality

Management
Quality

High

Successful I	Successful II
Unsuccessful III	Successful IV

Low

Moderate Average High

Team Success

Hypothesis 2

Club Success

The hypothesis of club success is evidenced by a higher proportion of the variation in club performance which is attributed primarily to management quality and players' qualities (players' talents).
The combination of the two elements can result in successful club in the following forms;

Successful Club

- High club success and high management quality

Unsuccessful Club

- Low management quality and moderate club success
- Low management quality and high club success
- High management quality and moderate club success

Management
Quality

High	Unsuccessful I	Successful II
Average	Unsuccessful III	Unsuccessful IV

Low

Moderate Average High

Club Success

Hypothesis 3

Club Success and Team Success

Thus the combination of the hypotheses 1 and 2 results in the hypothesis 3, i.e. the implication of success in both as a club and as a team is only attributed to high management quality and high team strength and high financial strength.

The hypothesis 3 is supported by the evidence of clubs (e.g. FC MU) a leading edge in sport industry worldwide. This fact is owed to its top quality management and team strength providing a sustainable team success and club success at national and international leagues.

CONCLUSION

We reviewed major part of literatures on; players' salaries versus team performance, the importance of sponsorship, marketing and advertising, commercialization of soccer teams, necessary contemporary changes in soccer business, i.e. recognition of the business processes such as procurement, marketing and management skills, the role of management in success or failure of the team and the club, the empirical correlation of team production function, coaching efficiency and team success, estimating the demand for professional team sports, trying to identify the objective function of professional clubs, and a few papers attempt to link the analysis of supply and demand conditions.

In this conceptual study, we defined the management quality as key success factor in team club success. We also defined the management quality as integration of performance by management team. Optimization of business processes at a soccer club is a tool in improving management quality. The hypothesis of club success is evidenced by a higher proportion of the variation in the club performance which is attributed primarily to quality of management and quality of players.

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USING AHP APPROACH IN DEVELOPING R&D CENTER RANKING METHODOLOGY

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ABSTRACT

With the rapid development of information technology and progress of the Internet in recent years, labor division has become more and more specialized all over the world; therefore, enterprises not only nurture local human resources but can also successfully introduce overseas technologies. In view of this, to acquire technology advantage and competence, an enterprise must be truly globalized to maintain its competitive edge among other competitors. Facing such change, a R&D institute also expands its business to procure technologies and resources overseas, thereby leading to R&D globalization. Thus, how to evaluate an optimal R&D center to minimize R&D costs and risk has become a major concern for enterprises. In order to help enterprise evaluate an optimal R&D center, this study develops a R&D center ranking methodology to identify the optimal R&D center using AHP approach. At last, this study employs an industrial computer development project as a case study for explanation and verification of practical contributions and efficiency of the methodology proposed in this study.

Keywords: R&D center, Analytical Hierarchy Procedure (AHP), R&D costs and risk

INTRODUCTION

As customer needs change fast and new products roll out quickly, enterprises have to speed up its product development and cut the time to market. Besides, the advance of information technology and required R&D resources scattered across the world have resulted in distributed product development, a company, in order to fully leverage on its advantages in technologies and resources, should develop itself as a multinational" R&D task force. Meanwhile, a R&D institute also sets up overseas R&D centers, which therefore catches up

the trend of R&D globalization. According to von Zedtwitzp and Gassmann (2002), companies in European countries launch approximately 30% of R&D globalization, among which only a few companies are engaged in over 90% of R&D globalization. From this trend, we may find that previous R&D projects, which were simple, independent and tactical, have evolved into interdependent overseas R&D activities with global coordination and strategic missions. In addition, with increased R&D globalization, enterprises can make the best use of foreign human resources and technologies to lower R&D costs, move closer to the market, understand market demands and make full use of local creative (Terpstra, 1977). To address the current environment of R&D globalization, enterprises should integrate R&D technologies and resources throughout the world to select an optimal R&D center for new product development. For this reason, how to select the optimal R&D center from those worldwide to minimize R&D labor and facility costs and to effectively mitigate the risk of timely completion of R&D missions and cost control has become a critical issue. To develop a ranking methodology of a R&D center, this study first creates a R&D center selection hierarchical structure, which is divided into two dimensions, namely cost and risk. The cost dimension includes R&D labor force expected cost and R&D facility expected cost, while the risk dimension consists of risk of timely completion and risk of cost control for R&D missions. Next, we calculate criteria weights in the dimensions using the Analytical Hierarchy Procedure (AHP) and apply the criteria weights to rank R&D center. In this way we may create a R&D center order preference to help enterprises select the optimal R&D center so that these enterprises can consolidate their competitive capacity by taking full advantage of global technologies and resources. At last this study employs an industrial computer development project as a case study for explanation and verification of the proposed methodology and its benefits.

The study's structure is described as follows. In Part II, we will summarize the criteria for evaluating R&D centers and the methodology; in Part III, we will depict the application of the AHP to develop a R&D center performance assessment model and the ranking methodology; in Part IV, we use an industrial computer development project as a case study for explanation; and in the last part, we elaborate the benefits of the proposed methodology.

LITERATURE REVIEW

Reddy (1997) proposes that a low R&D labor cost is a key factor for selection of a R&D center. John et al. (2006) suggest 39 factors associated with selection of a R&D center, including R&D personnel's technology capacity, know-how, tax and interest rate, etc.; they also identify relative importance of respective factors through questionnaire survey. Kumar

(2001) argues there are seven major evaluation criteria that attract multinational firms to establish R&D centers, including market scale (Agarwal and Ramaswami 1992; Brouthers and Brouthers 2000), R&D personnel's labor cost (Reddy 1997), technology specialization, government policy (Delios & Beamish 1999; Gomes-Casseres 1989), intellectual property protection and liberalization of trade. Sarkis and Sundarraj (2002) consider several criteria such as cost, time, R&D labor resource and risk to determine the location of a R&D center.

In terms of selection of alternatives, Saaty (1980) proposes the AHP, which may take both qualitative and quantitative criteria into account and calculate relative weights of each criteria and relative performance of each decision option, through an evaluation criteria hierarchical structure and pairwise comparison, to evaluate the optimal alternative. Today, the AHP has been widely used as a method for multicriteria decision-making (Dey and Gupta 2001; Mian and Christine, 1999; Loch and Kavadias 2002; Eugene and Dey 2005). Brenner (1994) uses an AHP to evaluate a R&D project and, depending on four criteria relating to customers and markets, groups R&D projects and selects the optimal one for investment. Crowe et al. (1998) propose an AHP-based methodology; they develop an ISO 9000 certified criteria and a hierarchical structure to help decision-makers measure performance of costs and benefits for ISO 9000.

From these literature reviews given above, few papers involved discussion about selection of a R&D center. This study therefore summarizes and creates a R&D center evaluation criteria structure and employs an AHP to develop a R&D center performance assessment model and a ranking methodology for enterprises to identify the optimal R&D center. With an industrial computer development project as a case study, we verify the feasibility of the proposed methodology in the last part.

METHODOLOGY

This study creates a R&D center performance assessment model and a ranking methodology and, by AHP, selects the optimal R&D center, such that each cost and risk of the R&D mission can be minimized. AT first, we summarize literature reports related to selection of a R&D center to identify important consideration criteria and then calculate criteria weights through AHP. This study divides evaluation criteria into cost dimension and risk dimension; the cost dimension includes R&D labor force expected cost and R&D facility expected cost, while the risk dimension consists of risk of timely completion and risk of cost control for R&D missions. Next, we integrate criteria weights into the AHP performance assessment model. With this approach, an order preference of R&D center can be created to help senior executives identify the optimal R&D center. Figure 1 shows the study's analysis process

structure.

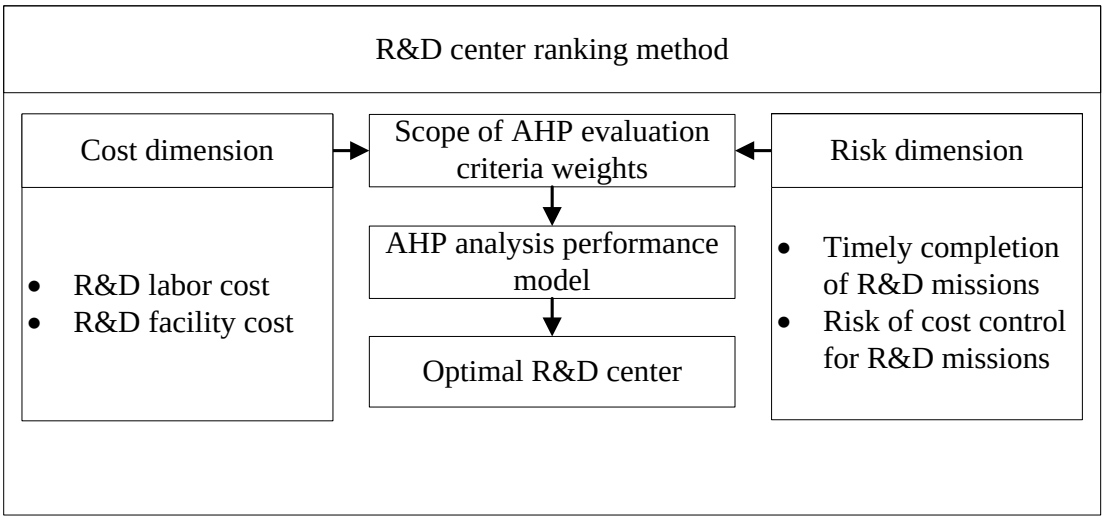

Figure 1: Analysis process of the methodology.

To examine relative weights of criteria for the selection dimension, this study employs the AHP proposed by Saaty (1980) to calculate relative weights of criteria. First, we use the nine-interval Likert scale to express the relative importance between Criteria *i* and Criteria *j*, as shown in Table 2, such that we can develop a pairwise comparison matrix [a_{ij}] as indicated in Formula (1).

Table 1: Nine-interval Likert scale.

Score	Linguistic variable
1	Equal importance
3	Moderate importance
5	Strong importance
7	Very strong importance
9	Absolute importance
2、4、6、8	Ranging between 1.3.5.7.9

Next, we use geometric mean to calculate the relative weight of Criteria *i*, as shown in Formula (2). Because the comparison of criteria relative importance is a subjective judgment, we should ensure consistency of the pairwise comparison matrix. According to Saaty (1980), if the consistence index (CI) of the matrix [a_{ij}] is less than 0.1, it suggests that the pairwise comparison matrix [a_{ij}] meets the consistency. Formula (3) shows a CI qualifying equation. To integrate various opinions from different decision-makers, this study uses geometric mean to acquire the final weights of respective criteria. Finally we integrate criteria weights into the AHP performance assessment model and calculate R&D center score (C_i^*), as shown

in Formula (4). This analysis result will be helpful to a company in selecting the optimal R&D center.

$$A=\left[a_{ij}\right]=\begin{bmatrix} a_{11} & a_{12} & \cdots\cdots & a_{1n} \\ a_{21} & a_{22} & \cdots\cdots & a_{2n} \\ & & & \\ a_{n1} & a_{n2} & \cdots\cdots & a_{nn} \end{bmatrix} \quad (1)$$

$$w_i=\left[\alpha_{i1}\otimes\cdots\otimes\alpha_{in}\right]^{1/n},\forall i \quad (2)$$

$$CI=\frac{\lambda_{\max}-n}{n-1}, \text{ where } \lambda_{\max}=(1/n)\left(\frac{w_1'}{w_1}+\frac{w_2'}{w_2}+\cdots+\frac{w_n'}{w_n}\right) \quad (3)$$

$$W'=AW$$

$$C_i^*=\sum_{j=1}^{m}a_{ij}b_j \quad i=1\cdots n \quad (4)$$

CASE STUDY

This study employs an industrial computer development project as a case study. The R&D project comprises three modules, namely software module, mechanism module, and electronic module. With assistance to top executives in evaluating the mechanism module of industrial computer R&D projects as an example, this study is intended to explain and verify the feasibility of the proposed methodology to minimize each R&D cost and risk.

To rank the performance of R&D centers, this study employs an AHP approach to integrate opinions from various experts and derive evaluation criteria weights with Formula (1)~(3) and ultimately obtain evaluation criteria weights through a consistency test. Table 2 shows weights of R&D center evaluation criteria. Subsequently, we apply criteria weights obtained with an AHP method to rating matrix by formulae (4), use the index C_i^* as a basis for making an order preference in this study, and determine the order preference of performance based on the C_i^* value. If the R&D center has the highest score, it is rated the ideal R&D center in this case. Table 3~6 shows the pairwise comparison matrix of R&D center in terms of the criterion. Table 7 shows the results of the order preference of R&D centers. Finally it is found that No.5 R&D center has highest $C_i^*=0.329$ value; thus No.1 R&D center is rated the ideal R&D center in this case. It is therefore suggested that the proposed methodology is helpful to an enterprise in selecting the optimal R&D center.

Table 2: The weights of R&D center evaluation criteria.

Dimension	Criteria	Codes	Weight
Cost	R&D labor cost (C1)	C1	0.509
	R&D facility cost (C2)	C2	0.309
Risk	Timely completion of R&D missions (R1)	R1	0.08
	Risk of cost control for R&D missions (R2)	R2	0.102

Table 3: The pairwise comparison matrix of R&D centers for the R&D labor cost.

C1 / R&D centers	1	2	3	4	5	Weight
1	1	2	4	1/2	1/4	0.159
2	1/2	1	2	1/2	1/4	0.105
3	1/4	1/2	1	1/4	1/5	0.058
4	2	2	4	1	1/2	0.241
5	4	4	5	2	1	0.438

Table 4: The pairwise comparison matrix of R&D centers for the R&D facility cost.

C2 / R&D centers	1	2	3	4	5	Weight
1	1	1/2	1/2	1/5	1/6	0.057
2	2	1	1	1/5	1/4	0.094
3	4	2	1	1/4	1/2	0.113
4	5	5	4	1	4	0.492
5	6	4	2	1/4	1	0.244

Table 5: The pairwise comparison matrix of R&D centers for timely completion of R&D missions.

R1 / R&D centers	1	2	3	4	5	Weight
1	1	1/8	1/2	1/2	1/5	0.050
2	8	1	7	5	2	0.485
3	2	1/7	1	1/2	1/5	0.067
4	2	1/5	2	1	1/4	0.099
5	5	1/2	5	4	1	0.300

Table 6: The pairwise comparison matrix of R&D centers for the risk of cost control for R&D missions.

R2 / R&D centers	1	2	3	4	5	Weight
1	1	6	1/2	4	5	0.314
2	1/6	1	1/5	1/4	1/2	0.046
3	2	5	1	5	7	0.447
4	1/4	4	1/5	1	4	0.133
5	1/5	2	1/7	1/4	1	0.059

Table 7: The order preference of R&D centers.

The number of R&D center	Criteria				Final score C_i^*	Rank
	C1	C2	R1	R2		
	0.509	0.309	0.080	0.102		
1	0.159	0.057	0.050	0.314	0.134	3
2	0.105	0.094	0.485	0.046	0.126	4
3	0.058	0.113	0.067	0.447	0.115	5
4	0.241	0.492	0.099	0.133	0.296	2
5	0.438	0.244	0.300	0..059	0.329	1

CONCLUSIONS

From the ongoing trend of R&D globalization, previous R&D projects, which were simple, independent and tactical, have evolved into interdependent overseas R&D activities with global coordination and strategic missions. Since an enterprise has to integrate R&D technologies and resources scattered throughout the world, how to select the optimal R&D center in such R&D circumstances has become a major concern. To address the problem, enterprises should use scientific decision analysis approaches to identify an optimal R&D center to accomplish their R&D missions and alleviate their R&D costs and risk as well. For this reason, this study proposes a R&D center performance assessment model and a ranking methodology; we develop a R&D center performance assessment model and a ranking methodology by AHP, aiming to help enterprises rank their R&D centers and select the optimal R&D center for integration of existing R&D technologies and resources, such that enterprises may minimize each R&D cost and risk. In the final part, this study employs an industrial computer development project as a case study for explanation and verification of practical contributions and feasibility of the proposed methodology.

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WHAT DO ENTREPRENEURS DO WHEN DEVELOPING OPPORTUNITIES? CRITICAL R&D INCIDENTS IN THE EVOLUTIONARY PATH OF A SMALL HIGH TECHNOLOGY FIRM

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ABSTRACT

The focus of the paper is on analyzing the innovation activities and related resource development strategies in shaping the evolutionary path of a small software firm. We have carried out a qualitative study of an entrepreneurial venture and interviewed entrepreneur and key personnel adopting the critical incident technique. We find that the role of the entrepreneur is significant during the early stages of innovation activities following technological changes. We also find evidence of the distributed agency perspective advocated by Garud & Karnoe (2003).

Keywords: bricolage, technology entrepreneurship, opportunity development, technological change, product line strategy

INTRODUCTION

It is widely acknowledged that in most high technology industries, innovation and knowledge creation are critical for firm growth (Nambisan 2002; Francis and Bessant 2005). Software industry can be considered as prototypical high technology industry characterized by innovation-driven market growth, rapidly shrinking product and technology life cycles, high knowledge intensity, and global markets. In a firm operating in this industry the nature and rate of innovation often shape its evolutionary path as well as its future growth. (Nambisan 2002, 141-145.) This paper is based on a research project that aims at a better understanding of the growth path of small software firms. The focus of the paper is on analyzing the innovation activities – identification, development and exploitation of opportunities – and related resource development strategies in shaping the evolutionary path of a small software firm. The research questions we address are: How were opportunities for innovation identified? Who participated in the development and exploitation activities, in which way, and what where the outcomes? In this paper we contrast entrepreneur-centered and distributed agency views on technology entrepreneurship.

THEORETICAL GROUNDING

Innovation is commonly considered a complex activity in which new knowledge is applied for commercial ends. Part of this knowledge reaches the firm from external sources. Studies have shown that for example customers have important information and that many innovations originate in the user domain. (von Hippel 2005; Chesbrough 2003.) According to Francis and Bessant (2005), in spite of its importance, innovation is often described narrowly: it is applied to changes to what a firm offers (product/service innovation) and to the ways it creates and delivers those offerings (process innovation). The authors point out that this definition is insufficient, as it does not take into account business models and market position, two of the areas where innovation is possible.

In essence the purpose of products and services is to create and deliver value for stakeholders. Ardichvili and colleagues (2003, 105-109) point out that identifying and selecting right opportunities for new businesses are among the most important abilities of a successful entrepreneur. Sensitivity to market needs in addition to ability to spot suboptimal deployment of resources may help an entrepreneur begin to develop an opportunity. Opportunities seen from the perspective of prospective customers represent value sought. Opportunities arising from resources, from technology or other types of proprietary knowledge or abilities may be labeled value creation capability. For example new technology may offer possibilities to value creation even though the precise forms that new value will take may be undefined. Ardichvili, Cardozo and Ray (2003; see also Klofsten 2005) have presented a process model of opportunity identification (Figure 1). The core process includes recognition of an opportunity, its evaluation and development per se. Authors point out that the development process is cyclical and iterative: an entrepreneur is likely to conduct evaluations several times at different stages of development which can lead also to recognition of additional opportunities or adjustment to the initial vision. Five major factors influencing this process include entrepreneurial alertness, information asymmetry and prior knowledge, social networks, personality traits of the entrepreneur (optimism, self-efficacy and creativity) and type of opportunity itself. According to authors the theory is expected to hold in the domain of new business creation and development, both as independent businesses and as new businesses created within existing corporations.

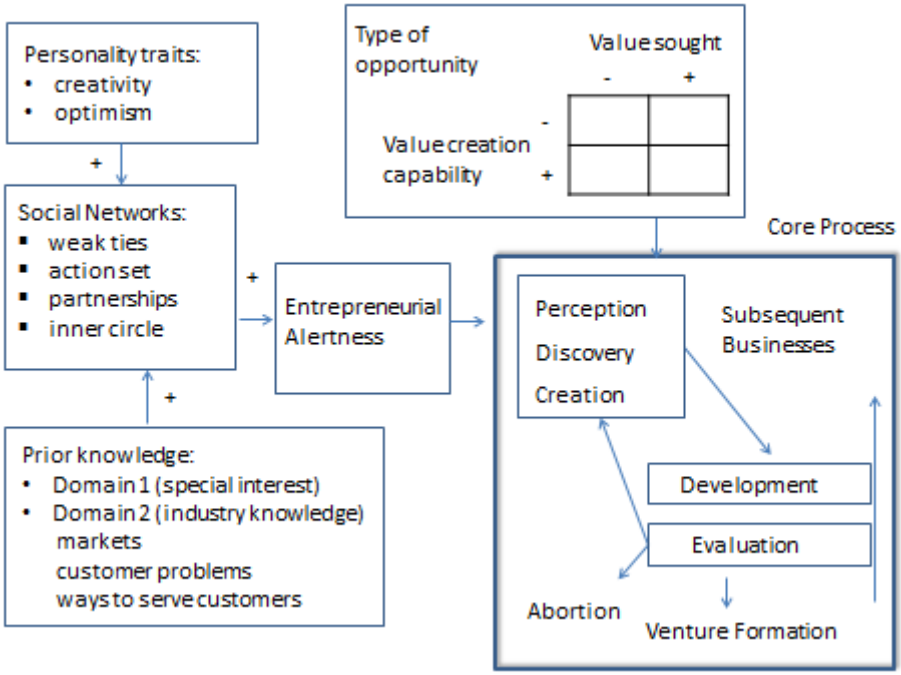

Figure 1: Model of opportunity identification and development (applied Ardichvili et al., 2003).

Ardichvili and colleagues represent the traditional entrepreneurship literature, which according to Garud and Karnøe (2003) primarily attributes the entrepreneurial success and failure to specific individual. In this literature entrepreneurial agency is located in a few individuals who have the full-blown ability to discover, create and exploit opportunities that lie beyond the reach of most. Departing from this conceptualization Garud and Karnøe (2003), who have studied the emergence of wind turbines in Denmark and in United States, suggest that technology entrepreneurship is a larger process that builds upon the efforts of many. According to these authors skills and resources required to take an idea from its inception to commercial use have to be mobilized by drawing upon the generative impulses of actors from multiple domains. In other words, they posit that entrepreneurial agency is distributed across actors each of which possesses "dispersed bits of incomplete and frequently contradictory knowledge". Actors include not only those who create and discover ideas, but also those who develop complementary assets, representatives of institutional forums and customers. Each actor becomes involved with a technology, and in the process, generates inputs that result in the transformation of an emerging technological path. The steady accumulation of inputs (artifacts, tools, practices, rules, knowledge) generates a momentum that enables and constraints the activities of distributed actors.

One source of business opportunity is new technology. Radical technology changes represent a break with past techniques and practice whereas incremental changes build on them. Radical changes introduce new design components combined in a system whose function relies on different knowledge base than previous products. Such changes create also challenges and they can be regarded as competence destroying because firm´s existing knowledge base is of limited relevance at best. A new technology is both physical and conceptual. It consists not only of the actual components and their associated testing and

production tools, but also a set of accumulated knowledge, techniques, and skills that set the agenda for further problem-solving and product refinement. (Jones 2003, 1265-1269.)

Referring to Wheelwright and Clark (1992) Jones (2003, 1269-1270) presents a three-category typology of development projects that characterizes their relationship to earlier projects. It is based upon a project´s level of continuity with existing products and processes. 1) derivative projects; share most with previous projects and their development requires only minor changes to existing products and/or processes, 2) radical projects; involve major change in product and process, often establishing a new product category for a firm and they represent a significant break with the past, 3) platform projects; is an intermediate category, which represents significant change in product or process, or more rarely, both. A platform is a base product that can be leveraged, perhaps successively over a significant time period to produce a family of related derivative products.

The competitive significance of the management of related products and product relationships has been emphasized in strategic managerial and innovation literature. In a technologically dynamic environment, firms must choose when to leverage existing platforms with derivative products and when to develop new platforms and/or replace existing platforms and their related derivatives. The overall result of these choices constitutes a firm´s product line management strategy, which can be characterized by the speed of product development and by the length of time each product is offered for sale. Together these factors reflect the rate at which products are replaced or renewed and the rate at which product lines are expanded. (Jones 2003, 1268-1270.)

Bricolage – assembling the resources to new challenges

According to Van de Ven (1986) to understand the process of innovation is to understand the factors that facilitate and inhibit the development of innovations. Critical challenge in small high-technology firms where technological capabilities determine if a firm can meet their R&D strategy is the problem of constructing resources for growth. Entrepreneurial (small) firms are typically resource and/or time constrained. Faced with these constraints, the standard make-or-buy decision of resource construction may not be relevant. (Banerjee & Campbell 2009; Street & Meister 2004.) Baker and Nelson (2005) have introduced entrepreneurial bricolage as the process by which resource-constraint firms are able to render unique services by recombining elements at hand. Bricolage is defined as a process of resource use and development characterized by using resources at hand, recombining resources and making do (Steffens and Senyard 2009; Baker and Nelson 2005).

According to Newbert (2008) firms need not necessarily possess rare resources and rare capabilities in order to attain a competitive advantage. Common resources can be as essential provided they are paired with other capabilities (or resources) in such a way that the resulting combination in which they are exploited is rare. Therefore firms may be able to build a competitive advantage from the resources and capabilities they already possess. In technology R&D the firm´s key resources that can be reallocated and recombined to address new opportunities are the skills embedded in inventors. (Banerjee & Campbell 2009, 474-475).

Baker and Nelson (2005, 353) point out that when a firm faces new challenges, whether opportunities or problems, without providing new resources it has basically three alternatives; seek new resources, avoid new challenge or engage in bricolage. In their study they find that 9 case firms out of 25 exhibited no discernable evidence of bricolage. These firms for example didn´t undertake offered job opportunity if they weren´t confident of being able to do it "the right way". Authors (2005, 358-359) have in their research utilized a definition by Stevenson and Jarillo (1990) of opportunity as "a future situation which is deemed desirable and feasible". For the firms they observed bricolage shaped both of these dimensions. Authors point out that alertness to resources is as important as alertness to opportunities. For example inventors in a firm will keep improving technology in a context of use until given a new context (Banerjee and Campbell 2009, 475).

Bricolage capabilities may help firms explore and exploit new opportunities that might appear too expensive to pursue through other means. When firms use bricolage more narrowly or temporarily, first rejecting and then enacting environmental resource limitations, they appear to be more likely to grow. This also suggest that firms may differ systematically in their ability to apply bricolage skillfully (Baker & Nelson 2005, 334, 342, 357) According to Duymedjian & Rüling (2010, 148) the distinctive competences of the manager-bricoleur include the capacity to sense (latent) connections, ability to get close to the reality of organized work, and dexterity in manipulating resources.

Ardichvili (2003, 111) and colleagues refer to Kirzner (1973) in their statement that entrepreneurs are selling not just products but rather, their knowledge, the ability to assemble resources, and the resources already available to them. This perspective allows entrepreneurs to move away from analyzing "what is" to discussion of "what is possible", and opens an opportunity for entrepreuneurial discovery. According to Garud and Karnøe´s results (2003, 296) concerning technology entrepreneuship bricolage was a process of moving ahead on the basis of inputs of actors who possessed local knowledge, through interactions, and by gradually transforming emerging paths to higher degrees of functionality. This co-shaping occurred at several interaction points, between designers and shopfloor workers, between producers and users, between external researchers and producers, and between policy makers and the markets that they regulated.

DATA AND METHODS

The focus of the paper is on analyzing the innovation activities – identification, development and exploitation of opportunities – and related resource development strategies in shaping the evolutionary path of a small software firm. To answer the research question, an empirical study using the critical incident technique has been carried out. The critical incident technique is a form of qualitative research that was originally developed by Flanagan. It has become a widely used research method which is utilized across number of diverse disciplines (Butterfield et al. 2005). In this study critical incident refers to an event that has had a significant effect (positive or negative) to the business activities.

The advantage of the CIT is that it can capture both opportunities (potential success) and risks (potential failure factors) and it generates detail descriptions that can identify links between different processes (Kaulio 2003, 196). Further advantages of CIT are for example

that it does not force the respondents into any given framework, it identifies even rare events that might be missed by other methods which only focus on common and everyday events. When looking at disadvantages the method relies on events being remembered by users and will also require the accurate and truthful reporting of them. The method also has a built-in bias towards incidents that happened recently, since these are easier to recall. (Butterfield et al. 2005; Chell 1998.)

Having the research focus on growth and on what kind of resource development strategies can be found "behind" this process, access to growth company was the first key point of the research. The first phase of selection process was based on publicly available information about growth figures (personnel, turnover) of small software firms. The present study was applied as a single case in order to perform a detailed data analysis and understand the case context. Final selection was based on the familiarity with the firm. One of the researchers has worked in the firm for a short period at the beginning of the 2000`s and has since that followed the development of the firm.

The case company is established in 1980`s and it operates in business-to-business niche market. The turnover was approximately 4.9 Million EUR in 2010. The firm consists of two divisions. One is focused on companies own products and the other more in consultant work and tailored products. During the interviews the company had 45 employees. Number of personnel has grown since that. In addition to own personnel the firm has also subcontractors and a growing international partner network, which consists mainly of sales personnel.

The empirical data consists of two pilot thematic interviews (Managing Director, Product Development Manager) done in June 2010 and five CIT based interviews conducted from September - November 2010. The latter ones consist of three individual interviews and two group interviews. The participants are listed in Table 1. Being a mature firm with long history some of the participants had over twenty years of work experience in the firm. The group interview was chosen as a method to help the memorizing of the shared past experiences and thus avoid the bias of reporting only resent incidents. The length of an interview varied between two and three hours. All interviews were tape recorded and later transcribed.

Table 1: Characteristics of the interviews and participants.

Title	Period of employment	Number of interviews	Type of interview
Managing Director	**Founder**	**2**	**individual**
Product Development Manager	**12**	**2**	**individual**
Manager, Consulting Services	**7**	**1**	**individual**
Productization Manager	**21**	**1**	**group 1**
Production Manager	**20**	**1**	**group 1**
Technical Specialist, Project Manager	**25**	**1**	**group 2**
Technical Support & Training	**24**	**1**	**group 2**

Our analytic strategy consists of three steps; identifying incidents, forming and analyzing categories. In analyzing the data we have mainly followed the protocol for credibility checks

introduced by Butterfield and colleagues (2005, 486-490). The checking procedure of the incidents meeting the criterion of inclusion in the study was done by checking the 1) antecedents information, 2) description of the experience itself and 3) the outcome of the incident. In the CIT study the sample size is not determined by the number of participants but by incidents reported. The point of exhaustiveness was achieved in the last interview when no new incidents were found.

At the basis of interviews 70 incidents were identified. Identification was a process done by group of three researchers. After independently identifying the incidents, the agreement level was checked. From each interview differing opinions was found approximately on 2-4 incidents. Final consensus about the 70 incidents was formed after all material was analyzed. Together these incidents form the "big picture" case history which is presented in the next chapter. Next step in analysis was grouping the incidents into categories of critical turning points in growth path of a small firm and finding whether or not regularities can be found. This stage was based on comparative examination – done independently and confirmed by agreement check. In analyzing the R&D related incidents further we have mapped out the actions taken by the entrepreneur and other actors and the outcomes achieved. By adding the details the history could provide a series of R&D "mini-cases".

RESULTS

From sideline job to international player – the development path of the case firm

The case company was founded in 1983 (CE1). Before starting the company, the entrepreneur had worked for three years to obtain customer industry knowledge and to establish customer networks. In the beginning, the entrepreneur continued to work outside the case company and it took two years before he engaged fulltime in developing the firm (CE2). At the same time, first external employees were hired (CE3). At the time, the firm development was slowed down by lack of ICT knowledge; both the entrepreneur and the employees were experts in the substance area, but did not have software development experience. Two years later, in 1987, the firm began to sell also consulting services and tailormade software, which is typical for software firms (CE4).

There were many important changes in operational environment at the coming of new decade. General standardization process of computers and operating systems (CE5) during the late 1980`s made it possible to use same software in different computers. As the need for tailoring diminished it released resources to development work. Case firm had focused from the outset in a niche market in which the use of platform software produced by a major stakeholder in the software industry was growing. Another important technological change was the new interface in this platform software (CE6), which opened up new possibilities for application development. In 1990 though the firm had a good portfolio of own products, the decision was made to start developing a new base product in this platform in cooperation with a partner firm "Alpha" (CE7). At the beginning of 1990´s Finland ended up in deep recession (CE8) but case firm managed to avoid financial decline by making market entry with consulting business in neighbouring market A (CE9).

In 1991 started a long-term (later subcontracting based) cooperation with start-up firm “Beta” (CE10) when a competent applications programmer exited a major industrial stakeholder and started his own firm after developing inside house -software in industry. This cooperation and decision to integrate knowhow complemented case firms coding expertise and helped directing operations to concentrating on chosen programming language (CE11). Year later case company ended the cooperation with firm “Alpha” and bought the source code (CE12). Development work related to new base product continued with firm “Beta” and other stakeholders also in the form of publicly funded development project A (CE13). At the time case firm got membership in developer network organized by platform product producer (CE14). When both offering and personnel were growing internal changes were made in organizational structure by separating the developer team of the new software from consulting team (CE15) in order to manage the information flow. Initial market entry of this new X -base product in domestic market was made 1994 (CE16) which was followed by an internationalization attempt with this own product to market A in trade fair (CE17) later in same year. Though this wasn´t a success concerning sales, initiate contacts with competitor firm “Gamma” and person A representing firm “Delta” about possible cooperation were made. At the time internal changes in the case firm continued as remote office in other city became established (CE18), sales function became professionalized (CE19) and firm joined the retailing network of the platform software (CE20). Exploratory cooperation started in trade fair with firm “Gamma” fizzled out (CE21). Another contact made with the representative of firm “Delta” was more fruitful end result being the establishment of joint venture (CE22) year after the first meeting. Marketing of X –base product in this new market area was boosted by localization of product (CE23).

Changes in operational environment characterize the latter part of the decade. There were signals of changing customer demands in international market. When a new development environment of platform software with better programming possibilities (CE24) was released in 1996 firm started to develop new base product (CE25) with a clean sheet in cooperation with firm “Beta”. Development work was also facilitated by participation in publicly funded development project B (CE26). This new Y -base product was from the beginning directed to international market which was expressed in that the market entry was done in market A instead of domestic market (CE27) in 1998. This was soon followed by initial market entry to market B based on connections made in development project B (CE28) and entering to market C (CE29). Case firm continued strong R&D work and new Y –base product turned into product family with market entry of derivative product 1 (CE30) in 2000. This was followed later by ending the development work of still successful X –base product (CE31) that was widely used in domestic market.

At the beginning of new century changes in business environment ended in tightening competition (CE32). Internationalization continued also in the domestic head office as the number of foreign personnel was growing significantly (CE32). Due to conflicting interests in market A with partner firm “Delta” case firm decided to acquire the ownership of joint venture (CE33). Market position A was further strengthened by major reference transaction (CE34). Internationalization continued by boosting of marketing in market C with new partner (CE35). Case firm continued also growing the product family based on needs of international customers. Year 2002 market entry of derivative product 2 (CE36) enlarged also the domestic clientele by being directed to new customer segment that traditionally

didn´t belong to a domestic target group of firm operating in this niche market. At the same time firm started also the development work with new platform that was used in consulting business (CE37). The offering continued extending when content creation services got more established (CE37) year later. Concerning internal organizational evolution the case firm faced also changes in form of domestic (CE38) and international (CE40) remote teams. New millennium was time of rapid internationalization through networking as the case firm entered market D in cooperation with partner firm "Epsilon"; a contact found through global developer network of the platform software producer (CE41). This was later followed by entering the market F with network connections (CE43) of this new partner firm.

Turbulence in business environment started few years earlier ended in crisis in cooperation with case firm and major stakeholder in the industry (CE44). Due to this turbulence in industry one major competitor exited the market by acquisition of this stakeholder (CE45). Case firm however managed to continue quite successfully in chosen path and proceeded in internationalization by seeking market entry to market G (CE46). Also the Y -product family got new member in the form of market entry of derivative product 3 to this base product (CE47). Year 2005 case firm participated in public development project (CE48) and made important internal development by developing software interface (CE49) and interoperability (CE50). Both crisis in cooperation with major stakeholder (CE51) and internationalization continued as case firm sought market entry to market H (CE52), market I (CE53) and market J (CE54). At the time international sales function become professionalized (CE55) and knowledge management improved (CE56). Marketing of Y – product family in market I and C was boosted by localizations of product (CE57 and CE58). Rapid growth continued both in the form of expanding the offering by making market entry of derivative product 4 (CE59) and by boosting marketing in market B with new partner (CE60).

In 2007 a significant change in operational environment was the release of the new platform software by aforementioned software industry stakeholder (CE61). Next year the case firm started development work of new base product (CE62) in this new platform, which helped also to revive the strategic cooperation (CE63). With growing personnel and offering firm made changes to licensing (CE64), delivery (CE65), knowledge management (CE66, CE67 and CE68) and organization (CE69) at the end of the decade. The market entry of new Z – base product was done in 2010 (CE70). The development of Y –product family is still the main priority and it is expected to continue also in the near future.

To summarize the development path of our case firm we identified 10 categories of incidents – internationalization, internal organization, expansion of offering, R&D, strategic alliance, change in operational environment, focusing of business, remote offices, public development cooperation, crisis in cooperation - that have had a significant (positive or negative) effect to the business activities of the firm. This firm has focused to a certain niche market and due to that and the small size of the domestic market, growth has mainly occurred in a form of internationalization. Essentially the development path of the firm mainly consists of alternation of growth elements (R&D and related expansion of offering, internationalization) and arrangements made in a way the firm operates (internal organization of firm, strategic alliances, focusing).

Entrepreneur -centred or distributed agency?

From the case history four major R&D projects that is “mini-cases” can be found, that have had significant impact to firm´s success (Table 2). Three of which have related strongly to particular technology change, and one to more general changes in technology. The role of the entrepreneur was significant concerning the early stages of innovation activities in every single one of them. It was the entrepreneur who had been alert to sensing the signals from different stakeholders about changing working culture and/or needs through networks and who by utilizing and combining this new information to prior knowledge started to assemble the needed resources to develop the opportunity. Concerning the personality traits of the entrepreneur, as part of the opportunity identification model created by Ardichvili and colleagues, every interviewed employee mentioned that the entrepreneur as a person and his drive to develop things further was the single most important thing for the success of the firm.

“The most important thing is managing director as a person. He has inexhaustible energy to develop things further. And he is also a really good seller. It is absolutely the single most important thing. And in the course of time he has been able to push the right buttons, knew what to do and to which market to enter. His eye for the game has probably been the most valuable thing.”

Table 2: The role and input of different actors in platform –level R&D projects.

Actors	**Technological opportunity 1**	**Technological opportunity 2**	**Technological opportunity 3**	**Technological opportunity 4**
Entrepreneur	identifying opportunity, starting and leading the development process, domestic network	identifying opportunity, starting and leading the development process, nordic network	identifying opportunity and starting the development process, international network	identifying opportunity, starting and leading the development process, international network
Consulting department	indirect input from customer understanding from tailored products	from no input to participation through tailored interoperability issues	learning new technology by doing, derivative services	learning standardized interoperability work by doing
Products department	learning new technology by doing, creating new base product and localization (1)	learning new technology by doing, creating new base product family; derivatives(4) and localizations (2)	learning and creating interoperability by doing	learning new technology by doing, interoperability, creating new base product
Platform software producer	New platform Provider of contacts, information, resources and credibility through developer and retailer networks	New interface Competitor after expanding to application production, exclusion from networks and resources	-	New platform software Partner seeking win-win – situation in application localizations, revival of developer partnership.
Developer partners	"Alfa"- complementary earlier experience on platform software "Beta" ; expert know-	"Beta" – first technical solutions together with entrepreneur, continuing participation in	-	"Beta" - first technical solutions together with entrepreneur, continuing participation in derivatives

	how on programming, first version of new technical solution in joint project, continued participation	derivatives		
Industrial partners and customers	Participation and funding in joint project	Growing importance in customer industry process and interoperability understanding, content creation	Needs to new solutions, partners in improving interoperability within industry, content creation	Growing importance in customer industry process and interoperability understanding, content creation
Substance area related stakeholders	Pioneer firms using the platform product, signals of changing culture in industry	Partners in improving interoperability within industry	-	Partners in improving interoperability within industry
Product customers and users	Contacts provided by domestic lead user led R&D project, cooperation in testing and development after the first released version	Continual cooperation in testing and developing (usability, needs) also with international lead users, needs from international customers for wider offering	Indirect input concerning interoperability needs	Signals from changing needs from international customers
Competitors	International forerunner´s example of possibilities with application to platform	International forerunner´s example of new dimension in applications	-	Benchmark knowledge from international competitors about wider vs. deeper markets
Public partners	Finance to joint project	Finance to joint project	Customer industry	Customer industry

	Customer industry regulations	Customer industry regulations, developer partners	regulations	regulations
Sales partners	National regulations and needs	National regulations and needs	-	National regulations and needs

Klofsten (2005) has analyzed the early process of ideas development in a newly started knowledge intensive firms. His main conclusions are in line with our results in that the technical skills of the founder(s) were decisive for the generation of new ideas and that the early process of idea development was is in many respects technique driven. Results are similar also concerning the first appearance from the data that having an idea seemed to be a random process, "don't remember where the idea came from", and beginning of development work quickly done, though in fact behind these two processes are years of mental work that makes a discovery possible.

All in all the product development work done in case firm has been visionary and the products created have from their own part had an effect also on the working culture of customers. In the late 1990`s the new software first even met resistance in domestic market because users had to renew their way of working. There was no pressure from domestic market to renew the offering at that time. Still the entrepreneur made the decision to stop the development of the old base product and concentrate resources to developing new product family. This is in line with Nambisan´s (2002) results concerning the evolvement of software firms where the author posited that the first prerequisite for a firm to evolve is the positive attitude towards pursuing technology leadership and envisioning a clear technology development path by top management. In the case firm the signs from change in customer industry came from international competitors which were much bigger firms acting on different scale. The created software was however technologically transcendent and the small nameless firm managed to made breakthrough.

When looking at the stage of opportunity exploitation, the pattern of entrepreneur led prototyping done by a small group characterized the way how every major R&D project began. So also this first stage when resources beyond time were used was based on and led by the vision of the entrepreneur. Executing the vision may require also calculated risks because besides offering a business opportunity new technology is also risk by being competence destroying (see Jones 2003; Nambisan 2002). Every four major R&D projects required learning by doing from the employees of the firm. Even when trying to get education it might not be available. Networking and strategic alliances have been the way to complement knowledge base and speed up the development.

"You just have to learn the hard way. We didn´t know how to use it (platform software). We participated to some courses, but both were equally lost. Those courses were quite vapid."

"He was an expert programmer and we were just engineers. He was more competent and we decided to join our forces."

Though the beginning of the innovation process has been strongly in the hands of the entrepreneur, one of the biggest strengths of the firm (or entrepreneur) has been the capability to recognize the importance of different stakeholders and get them to participate in creation of new technology. The substance area is regulated by national standards which guide the work of different customer segments. This meaning that in new market area you have to have knowledge not only about customer needs but also about local regulations, which highlights the need for good partners.

"We just kind of an early stage started export business and this way started to understand the importance of communication. That you really have to be able to interpret the messages the opposite firm is sending, and to understand that things aren´t necessarily as they say. We also have reached an understanding that this line of business consists of many stakeholders. We have to scan the market throughout. It has forced to think quite diverse about things."

When looking at the R&D cases, the number and role of different partners has grown in three major R&D projects related to own products. In 1990`s the firm developed first versions of software together with a small start-up partner firm and later on together with a domestic lead user customer and made first experiments in international market. The next R&D project wasn´t just about usability or new attributes related to certain software, but the important development questions had to do with interoperability concerning whole customer industry. In these later R&D projects the role of major stakeholders comes close to Garud and Karnøe´s (2003) perspective on technology entrepreneurship as involving agency. In questions of improving interoperability the development has been a process that is based on stakeholders having local knowledge about their substance area and providing inputs through interactions to mutual development process where different stakeholders are gradually transforming not only functionality of a certain software product but also common industry way of action.

CONCLUSIONS

The role of the entrepreneur was significant concerning the early stages of innovation activities related to technological changes that opened up new opportunities. Every major R&D event it was the entrepreneur who identified the opportunity, started and (mostly) led the early process. Concerning the personality traits of the entrepreneur every interviewed employee mentioned that the entrepreneur as a person and his drive to develop things further was the single most important thing for the success of the firm. To summarize it can be said that the process model of opportunity identification presented by Ardichvili and colleagues that links the agency to the entrepreneur helped to shed light to question about identifying the right opportunities.

The importance of networks was significant not only as an antecedent of entrepreneurial alertness and opportunity identification as in model created by Ardichvili and colleagues but also in exploiting the opportunities. Though the firm managed several times to rose up to the challenge of using existing resources to new purposes, external networks were critical. At earlier R&D projects these helped not only in understanding market requirements but also in filling critical internal technology gaps. In recent development work the role of these stakeholders has come closer to creating common processes that have impact to evolution of whole industry. From this point of view there are implications that the entrepreneur-centred viewpoint is too narrow concerning innovation activities in the context of technology entrepreneuship.

The interview material didn´t provide much information how the opportunity development proceeded and which actors participated when moving ahead from opportunity identification towards more concrete business opportunity. The details of actions made

before committing other resources than the time of an entrepreneur and other actors are not known. This shortcoming can at least partly be explained by the fact that being a mature firm with a long history it was a challenge both to interviewer and participants to go through the major events that had shaped the evolutionary path of the firm during almost thirty years.

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THE INFLUENCE ON CORPORATE ENTREPRENEURSHIP OF TECHNOLOGICAL VARIABLES.

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ABSTRACT

The appearance of the Internet in the economy in the 1990s, has let in today's globally competitive environment, a tremendous expansion in technology for business and rapid growth in investments (Skerlavaj and Dimovski, 2006) and assessing the value of technology has never been easy. Then, the aim of this paper is to highlight the importance of different technological aspects of organizations on high technology Spanish firms´ performance. To obtain perfect adaptation of the firm to its environment, it is crucial that managers develop the corporate entrepreneurship to improve high technology sector firms´ performance. The paper shows the important role of top manager's support on technological distinctive competencies and organizational learning. Success in this kind of aspects is of vital importance to the corporate entrepreneurship in the firm.

The studied relationships are empirically confirmed by using a structural equation model to demonstrate our hypotheses. The sample was selected from the database Dun & Bradstreet España in 2005, obtaining 201 Spanish firms. Finally, CEOs were our main informants.
To sum up, the paper seeks to stimulate new lines of research regarding one variable (technological distinctive competencies) and relate it to other constructs, producing new relationships and observing their repercussions for the firm.

Keywords: Technological Distinctive Competencies, Top Management Support, Organizational Learning, Corporate Entrepreneurship, Organizational Performance.

INTRODUCTION

The 1990s might well be considered the beginning of the era called the new or e-economy because of the appearance of the Internet in the economy, which has let in today's globally competitive environmºent, a tremendous expansion in technology for business and rapid growth in investments (Skerlavaj and Dimovski, 2006).

Assessing the value of technology has never been easy. The application of technology throughout the company (Andreu and Ciborra, 1996; Giarratana and Torrisi, 2010; Leonard-Barton, 1992) has increased the importance of Technological Distinctive Competencies

(TDCs), which permit exploitation of the technological opportunities for the development of corporate entrepreneurship, the reduction of costs and the generation of organizational competitive advantage (Alvarez and Barney, 2007; Autio *et al*., 2000; Real *et al*., 2006; Woolley, 2010).

In this research, TDCs represent "the organization's expertise in mobilizing various scientific and technical resources through a series of routines and procedures which allow new products and production processes to be developed and designed" (Real *et al*., 2006, p. 508).

This research contribute to the previous research by joining TDCs to other strategic constructs, such as the necessity of Top Management Support of technology (briefly TMS) to obtain these competencies, or the learning processes needed all over the organization, analyzing globally and empirically their repercussions for the corporate entrepreneurship so as to achieve a higher value firm. Thus, the study seeks first to analyze empirically the influence of TMS on TDCs (e.g., Byrd and Davidson, 2003; Haro *et al.*, 2010). Secondly, we seek to analyze how these TDCs and TMS influence organizational learning (OL) (Alvarez and Barney, 2007; Autio *et al*., 2000; Leonard-Barton, 1992; Shane and Venkataraman, 2000; Teece, 1986; Woolley, 2010). Thirdly, we try to analyze the direct relationships between both TDCs and OL on corporate entrepreneurship (Alvarez and Barney, 2007; Leonard-Barton, 1992; Woolley, 2010). Organizations that engage in entrepreneurial activities achieve higher levels of growth and profitability than organizations that do not, thus also achieving higher organizational performance (Antoncic and Hisrich, 2001). Corporate entrepreneurship involves "extending the firm's domain of competency and corresponding opportunity set through internally generated new resource combinations" (Covin and Slevin, 1991, p. 1). Thus, corporate entrepreneurship refers to ''the process by which firms notice opportunities and act to creatively organize transactions between factors of production so as to create surplus value'' (Jones and Butler, 1992, p. 735).

All of these technological variables demand strong and committed TMS to guide the initiative and develop a working environment that supports technology (Ghosh *et al*., 2001). TMS "reflects, in many ways, the importance that top management executives place on technology" (Byrd and Davidson, 2003, p. 246). For Leonard-Barton and Deschamps (1988, p. 1254), TMS is a "perceived powerful source".

TDCs influence corporate entrepreneurship, improving organizational performance. In addition, TDCs impact corporate entrepreneurship directly because they permit entrepreneurs to earn their status by demonstrating excellence in technological and professional skills and knowledge (Leonard-Barton, 1992). TMS has been closely linked to TDCs (Byrd and Davidson, 2003; Ghosh *et al*., 2001; Leonard-Barton and Deschamps, 1988).

Although corporate entrepreneurship is directly influenced by TDCs, it may well be also influenced through OL (Benitez *et al*., 2010; Chenhall, 2005; González and Nieto, 2005; Leonard-Barton, 1992; Omerzel and Antoncic, 2008; Rerup, 2005), since OL disseminates and uses the learnt knowledge to encourage entrepreneurial behavior (García *et al*., 2006; Senge *et al*., 1994). OL can be considered a process whereby members in an organization are stimulated to strive continually for new approaches and acquire, as well as to share

knowledge consequential to interactions with environments (Argyris, 1993; Nonaka and Takeuchi, 1995).

In the section on hypotheses, we draw on prior research to develop a number of testable hypotheses concerning the influence of TMS on TDCs, the influence of TMS and TDCs on OL, the influence of TDCs and OL on corporate entrepreneurship, and the way corporate entrepreneurship improves organizational performance. That section serves as the theoretical foundation for the paper. The next sections present the research methodology and discuss the results. The final section makes some concluding observations and points out some of the study's limitations and lines for future research.

HYPOTHESES

The influence of TMS on TDCs and OL

TMS has long been recognized as one of the most important factors for ensuring successful implementation of distinctive competencies (Byrd and Davidson, 2003; Ghosh *et al*., 2001; Leonard-Barton and Deschamps, 1988; Petroni and Panciroli, 2002). It reflects the importance that the top management executives place on technology competencies (Byrd and Davidson, 2003).

TMS helps the firm to obtain more TDCs and competitive advantage in key business areas (Byrd and Davidson, 2003). An innovation-supportive culture from top managers can generate higher business value (Petroni and Panciroli, 2002), which is translated into higher TDCs in the firm (Benitez *et al*., 2010).

In the technological innovation literature, management support is seen as an important power-tool to promote TDCs (Kanter, 1984). Zmud (1984) finds that managerial influence is stronger for technological innovations, because they require more skilled individuals who may achieve excellence in technology (Leonard-Barton and Deschamps, 1988).

Torkkeli and Tuominen (2001) found TMS to be seen very advantageous and appropriate to core competency-based technology because it offers many potential benefits for supporting core distinctive competency-based technology, such as skilled technological entrepreneurs (Antoncic, 2007), exceptional skills managers (Leonard-Barton, 1992) and better-trained employees (Andreu and Ciborra, 1996; Torkkeli and Tuominen, 2001).

Such support is vital to obtaining TDCs and the successful implementation of TDC strategies to improve competitiveness, as well as to achieving a sustainable competitive advantage that is truly difficult to imitate (Haro *et al.*, 2010). Then, in the light of the foregoing, the following hypothesis is proposed:

Hypothesis 1: TMS will be positively related to TDCs in technological organizations.

TMS is one of the most important factors of systematic knowledge management and OL. Omerzel and Antoncic (2008) studied TMS in small and medium-sized enterprises and concluded that one person is usually in charge of OL, combining both knowledge ownership

and the managerial function. For them, the main manager is the person who provides employees with a knowledge technological framework by means of an OL process. Fineman (1996) provides insight into the influence of TMS as it plays a key role in shaping the climate for such a learning culture. Managers should understand company culture and values, and they should maintain what is good and promotes knowledge creation through an OL process. This can be achieved if the manager is willing to observe and talk to employees, to recognize obstacles, problems and success, and to train employees (Leonard-Barton, 1992). Top management characteristically requires different knowledge in different growth periods and thus continuously develops its OL process so as to obtain that knowledge (Omerzel and Antoncic, 2008).

Furthermore, expert managerial culture may provide an overarching frame of reference, helping to align employees' behavior who, if implement a technology-supportive culture, will have more precise knowledge of the organizational objectives for innovation and will make a greater effort to achieve these objectives more efficiently, (Andreu and Ciborra, 1996; Leonard-Barton, 1992) provided by top management (Chenhall, 2005). In practice, top management designs OL processes for employees to learn and, consequently, the firm may well be able to obtain a competitive advantage that it would otherwise not achieve (González and Nieto, 2005).

Successful managers develop various practical skills during their work and exert considerable effort on building support systems for disseminating knowledge technological and initiating an OL process to teach it (Andreu and Ciborra, 1996; Leonard-Barton, 1992; Omerzel and Antoncic, 2008).

TMS permits the organization to learn through experimentation, communication, dialogue, personal mastery and the process of organizational knowledge creation in order become an intelligent organization (Leonard-Barton, 1992; Lloréns *et al*., 2005). Consequently, OL needs strong technological commitment and TMS to achieve competitive advantage (Lei *et al*., 1999; Lloréns et al., 2005). Based on this prior literature, we propose the following hypothesis:

Hypothesis 2: TMS will be positively related to OL in technological organizations.

The influence of TDCs on OL and corporate entrepreneurship

Technological competencies are one important element of the core competencies of the firm. Management usually strengthens these TDCs as a means to nurturing strengths in technological knowledge and production routines to exploit potential outcomes, create potential markets and beat potential competition (Banerjee, 2003).

TDCs may become institutionalized over a long period of time and form part of the company's knowledge creation system (Leonard-Barton, 1992). Andreu and Ciborra (1996) share this idea and observe that the development of central competencies (e.g. TDCs) is linked to the process of OL. TDCs constitute the roots of a firm's sustainable competitive advantage, since the competencies comprise patents protected by law, technological

knowledge, and production skills that are valuable and difficult for competitors to imitate (Lee *et al*., 2001). Such competencies are obviously even more central in high-technology firms because they comprise technological knowledge—internal know-how generated by R&D and other technology-specific intellectual capital such as OL (Lee *et al*., 2001). OL programs make possible effective incorporation of the firm's TDCs into the firm's organizational context, making them apparent on all organizational levels and giving them meaning (Andreu and Ciborra, 1996).

Along similar lines, Real *et al*. (2006) state that developing competencies involves OL about how to combine and use resources, as well as the learning already embedded in the organizational routines employed.

An educational system or OL program is required for the entire production staff, involving both classroom education and on-the-job training to exploit technological competencies (Alvarez and Barney, 2007; Leonard-Barton, 1992). Management actions aim at giving learning processes the appropriate direction at any point in time (Argyris, 1993). The goal is for employees to understand TDCs (Real *et al*., 2006) on all levels of the organization so that the organization can obtain a competitive advantage and stand out from its competitors (Real *et al*., 2006). Based on this literature, we propose the following hypothesis:

Hypothesis 3: TDCs will be positively related to OL in technological organizations.

TDCs are typical of entrepreneurs who support the generation of corporate entrepreneurship. These entrepreneurs have exceptional skills or distinctive competencies that enable corporate entrepreneurship by distinguishing the technological competencies. Entrepreneurs are able to invent their way out of difficulties using their technological excellence (Leonard-Barton, 1992). TDCs enable entrepreneurship (Leonard-Barton, 1992; Rerup; 2005).

Technology-intensive firms should be more flexible in order to combine their technology with other complementary assets, such as competencies in exploiting international growth opportunities (Autio *et al*., 2000; Haro *et al.*, 2010). Woolley (2010) applies this insight to technological firms and underscores that TDCs provide opportunities for entrepreneurs in the firm. Technological competencies provide an ownership advantage that enables entrepreneurs to increase the firm's likelihood of survival (Giarratana and Torrisi, 2010).

TDCs are a necessary but not a sufficient condition for generating a sustainable competitive advantage (Giarratana and Torrisi, 2010). Such advantage requires that TDCs be combined with other complementary assets that the firm may or may not be able to develop or acquire and which could have negative consequences for profitability (Teece, 1986).

Thus, the entrepreneur must take existing technological knowledge and assimilate it to obtain TDCs. The entrepreneur must identify potential market opportunities and then act upon them (Woolley, 2010) to obtain an outstanding advantage. TDCs are thus a brilliant way for entrepreneurs in the corporation to demonstrate their technological knowledge. Consequently, we formulate the following hypothesis:

Hypothesis 4: TDCs will be positively related to corporate entrepreneurship in technological organizations.

The influence of OL on corporate entrepreneurship

OL models are usually appropriate for the study of corporate entrepreneurship (García *et al*., 2006; Yang and Rui, 2009). When used strategically, OL and information systems promote entrepreneurial actions by efficiently filtering, sorting, routing, and contextualizing relevant information for senior managers (Simsek *et al*., 2009). Simsek *et al*. (2009) consider OL to be a central mechanism in an organization, a mechanism that is likely to grant the firm an adaptive advantage via corporate entrepreneurship.

Many organizations make considerable efforts to build systems for acquiring and disseminating knowledge, developing OL processes for all employees in the firm so that they may achieve corporate entrepreneurship (Leonard-Barton, 1992; Omerzel and Antoncic, 2008). If an organization wishes to have well-constructed corporate entrepreneurship, entrepreneurs should view the need for different knowledge in different growth periods as characteristic and thus continuously develop OL processes to satisfy their need for knowledge (Omerzel and Antoncic, 2008).

OL is normally analyzed as an antecedent of entrepreneurship, which increases the organization's capability to carry out actions to improve organizational performance (e.g., García *et al*., 2006; Yang and Rui, 2009). In addition, corporate entrepreneurship requires an OL framework that involves search activities such as expending resources on the exploration of alternative possibilities, attempting to understand the relationship between organizational characteristics and outcomes, and determining the viability of organizational change (García *et al*., 2006; Lant and Mezias, 1990). Thus, information flows lead us to know that OL is expected to be positively related to corporate entrepreneurship (Antoncic, 2007; Antoncic and Hisrich, 2001; Yang and Rui, 2009). Based on the previous literature, we formulate the following hypothesis:

Hypothesis 5: OL will be positively related to corporate entrepreneurship in technological organizations.

The influence of corporate entrepreneurship on organizational performance

Corporate entrepreneurship is a strategic variable in successful organizations (Antoncic and Hisrich, 2001; Antoncic and Prodan, 2008; Kanter, 1984). It is positively related to the firm's growth and profitability (Covin and Slevin, 1991; Zahra, 1993). Organizations that engage in entrepreneurial activities achieve higher levels of growth and profitability than organizations that do not (Antoncic and Hisrich, 2001). A study by Zahra and Garvis (2000) shows that international corporate US companies' entrepreneurship was positively associated with the firm's overall profitability and growth, as well as its foreign profitability and growth. Furthermore, corporate entrepreneurship enables organizational performance (Antoncic and Prodan, 2008). Entrepreneurs, who identify their firms' positions in the competitive network of the industry correctly, strengthen and engage new sales, financial capital and important decisions, about alliances and joint projects (Batjargal, 2007). Wood

and McKinley (2010) suggest that entrepreneurs are not simply filters and interpreters of information; rather, they are an integral part of opportunity emergence, as they invent part of what they believe to be viable in order to improve organizational performance (Wood and McKinley, 2010).

Nevertheless, it is not expected that all firms will demonstrate strong corporate entrepreneurship and, then, a higher performance (Lengnick-Hall, 1992). For instance, some organizations avoid responding to the need for change as long as possible (Lengnick-Hall, 1992).

For technological organizations, various current studies indicate a positive relationship between corporate entrepreneurship and organizational performance. Pearce *et al*. (2010) assert that corporate entrepreneurship has a positive effect on commercial organizations, as it leads to a beneficial first-mover advantage. Audretsch *et al*. (2008) show that positive economic performance in high-tech or Information and Communication technology companies depends on entrepreneurship capital, the capacity of a region to support entrepreneurs. Based on previous literature, the following hypothesis is proposed:

> *Hypothesis 6: Corporate entrepreneurship will be positively related to organizational performance in technological organizations*.

METHODOLOGY

Sample and Procedure

The population for this study consisted of technological organizations possessing the greatest turnover in Spain. Technological organizations are firms which put emphasis on an orientation towards R&D, on innovativeness and entrepreneurship and maintain a special pattern of work relations (the corporate culture of technology). These elements describe shared values, beliefs and symbols, and the way things are done in the firm (Grinstein and Goldman, 2006). The sample was selected by means of a stratified sampling with proportional allocation (size and geographical location) from the database Dun & Bradstreet España (2005). Choosing a sample of firms located in a relatively homogeneous geographical, cultural, legal and political space enables us to minimize the impact of the variables that cannot be controlled in the empirical research. The Spanish market is relatively well developed and wholly integrated in the European Union. However, Spain is in a geographical area that has received relatively little attention from organizational researchers in the field of technological competencies.

We developed a structured questionnaire for sending it to CEOs of the organizations. CEOs were our main informants, since they constitute a valuable source for evaluating and molding the different variables under study throughout the organization by determining the types of behavior that are expected and supported (Baer and Frese, 2003).

Surveys were mailed to the 1000 selected organizations along with a cover letter. We used this method because it enabled us to reach a greater number of organizations at a lower cost, to exert less pressure for immediate reply, and to provide the interviewees with a

greater sense of autonomy. The cover letter explained the goal of the study and offered recipients the option of receiving the results once the study was completed. It also explained that all responses obtained in the questionnaires would be used on an aggregate level to prevent the identification of any organization in order to reduce desirability bias.

We mailed each manager who had not yet responded two reminders. 226 valid questionnaires were returned, but because of missing values only 201 questionnaires were included in the research. The response rate was 20.1 % (Table 1) without significant difference between early and late respondents. Characteristics of the responding businesses were compared to those of the non responding businesses to reduce the possibility of non-response bias. The results for return on assets, return on equity, return on sales and number of employees indicated that there was no significant difference among respondents and non respondents. Nor did we find significant differences due to geographical location or size in the variables studied in the different tests, such as the chi-square and t-tests. Since all measures were collected with the same survey instrument, the possibility of common method bias was tested using Harman's one-factor test (Konrad and Linnehan, 1995). A principal components factor analysis of the questionnaire measurement items yielded four factors with eigenvalues greater than 1.0, which accounted for 71 percent of the total variance. A substantial amount of method variance does not appear to be present, since several factors, not just one single factor, were identified and because the first factor did not account for the majority of the variance (Podsakoff and Organ, 1986).

Table 1: Technical details of the research.

Sectors	High-tech services (computer science activities, research and development services, postal and telecommunications services), high-tech manufacturing (chemical industry; aerospace construction; radio, television and communication manufacture; office machinery and computer science equipment; medical instruments, precision optics and watches)
Geographical location	Spain
Methodology	Structured questionnaire
Procedure	Stratified sample with proportional allocation (size)
Universe of population	50,000 firms
Sample (response) size	1000 (201) firms
Sample error	6.9%
Confidence level	95 %, p-q=0.50; Z=1.96
Period of collecting data	From April 2010 to May 2010

Measures

Given that developing new constructs or scales of measurement is a complex task, wherever possible we use pre-tested constructs from past empirical studies to ensure their validity and reliability. Subsequently, we performed an exploratory factor analysis using the method of extraction of principal components with varimax rotation obtaining the five factors of our study clearly framed (Table 2).

Table 2: Exploratory factor analysis.

Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
MANSUP1		0.820			
MANSUP2		0.720			
MANSUP3		0.753			
MANSUP4		0.782			
TECCO1	0.798				
TECCO2	0.666				
TECCO3	0.721				
TECCO4	0.783				
TECCO5	0.732				
TECCO6	0.427				
ORLEAR1			0.783		
ORLEAR2			0.801		
ORLEAR3			0.784		
ORLEAR4			0.662		
COREN1					0.538
COREN2					0.849
COREN3					0.553
COREN4					0.817
PERFO1				0.857	
PERFO2				0.863	
PERFO3				0.875	
PERFO4				0.589	
PERFO5				0.570	

TMS: Using scales established by Byrd and Davidson (2003) and Ray *et al*. (2005), we drew up a four-item scale (Appendix) to reflect TMS. We developed a confirmatory factor analysis to validate our scales (χ^2_2=11.42; NFI=.99; NNFI=.98; GFI=.99; CFI=.99). The scale was one-dimensional and showed high reliability (α=.926).
TDCs: Using scales established by Real *et al*. (2006), we drew up a six-item scale (Appendix) to reflect TDCs in the organization. We developed a confirmatory factor analysis to validate our scales (χ^2_9=19.39; NFI=.99; NNFI=.99; GFI=.99; CFI=.99). The scale was one-dimensional and showed high reliability (α=.917).

OL: We used the scale of four items developed by Aragón *et al*. (2007) and García *et al*. (2006, 2008) to measure OL (Appendix). These items have been duly adapted to the present study. We developed a confirmatory factor analysis to validate the scales (χ^2_2=5.74; NFI=.99; NNFI=.99; GFI=.99; CFI=.99) and showed that the scale was one-dimensional and had adequate validity and reliability (α=.908).

Corporate Entrepreneurship: We used five items developed by Knight (1997) to measure proactiveness, five items developed by Zahra (1993) to measure new business venturing, eight items developed by Zahra (1993) to measure self-renewal, and six items developed by Zahra (1993) to measure organizational innovation. These items have been duly adapted to the present study (Appendix). A 7-point Likert scale (1 '*totally disagree'*, 7 '*totally agree'*) for this and all prior variables allowed managers to express agreement or disagreement. We calculated the arithmetical mean of these items (a high score indicated good level of proactiveness, new business venturing, self-renewal and organizational innovation) and obtained a four-item scale of corporate entrepreneurship. We developed a confirmatory factor analysis to validate the scale of corporate entrepreneurship (χ^2_2=16.39; NFI=.98; NNFI=.95; GFI=.99; CFI=.98) and showed that the scale was unidimensional and had adequate validity and reliability (α=.867).

Organizational Performance: We used the scale of five items developed by Murray and Kotabe (1999). The use of scales for evaluating performance relative to the main competitors is one of the most widely-employed practices in recent studies (e.g., Choi *et al*., 2008). Many researchers have used managers' subjective perceptions to measure beneficial outcomes for firms. Others have preferred objective data, such as return on assets. The literature has established widely that there is a high correlation and concurrent validity between objective and subjective data on performance, which implies that both are valid when calculating a firm's performance (Homburg *et al*., 1999; Venkatraman and Ramanujan, 1986). We included questions involving both types of assessment in the interviews, but the CEOs were more open to offering their general views than to offering precise quantitative data. When possible, we calculated the correlation between objective and subjective data, and these were high and significant. We developed a confirmatory factor analysis to validate the scales (χ^2_5=34.92; NFI=.97; NNFI=.95; GFI=.98; CFI=.97) and showed that the scale was unidimensional and had high reliability (α=.867). We used a Likert-type 7-point scale (1 *"Much worse than my competitors,"* 7 *"Much better than my competitors"*) to ask about the organization's performance as compared with that of its most direct competitors.

Model and analysis

Data were analyzed through a structural equation model (LISREL 8.30 program) to determine the existence of exogenous latent variables (TMS [ξ_1]), first-grade endogenous latent variable (TDCs [η_1] and OL [η_2]), second-grade endogenous latent variables (corporate entrepreneurship [η_3], organizational performance [η_4]) and to establish the causal relationships among these variables. This process allowed us to translate the theoretical constructs into mathematical models so that the constructs could be estimated and evaluated empirically (Jöreskog and Sorbom, 1996). The hypotheses are plotted graphically in the theoretical model presented in Figure 1. We used a recursive non-saturated model. Structural equation modeling takes into account errors in measurement, variables with multiple indicators and multiple-group comparisons.

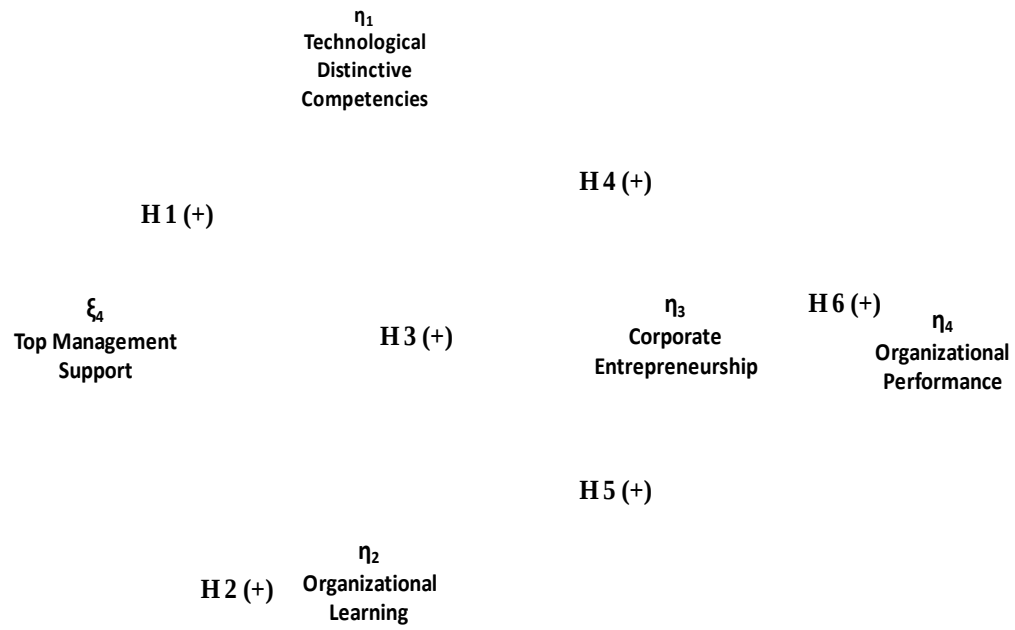

Figure 1*: Hypothesized model*.

RESULTS

In this section, we present the main research results. First, Table 3 shows the means and standard deviations as well as the inter-factor correlation matrix for the study variables. There are significant and positive correlations among TMS, TDCs, OL, corporate entrepreneurship and organizational performance.

Table 3: Means, standard deviations and correlations.

Variable	Mean	S.D.	1	2	3	4	5
1. Top Management Support	4.706	1.438	1.000				
2. Tech. Dist. Competencies	4.664	1.273	.748***	1.000			
3. Organizational Learning	4.791	1.404	.670***	.681***	1.000		
4. Corporate Entrepreneurship	4.339	1.154	.637***	.639***	.641***	1.000	
5. Organizational Performance	4.477	0.987	.390***	.466***	.464***	.505***	1.000

Note: *p<.05;**p<.01;***p<.001(two-tailed). n=201

Second, structural equations model was performed to estimate direct and indirect effects using LISREL with the correlation matrix as input. This type of analysis has the advantage of correcting for unreliability of measures and also gives information on the direct and indirect paths between multiple constructs after controlling for potentially confounding variables. Figure 2 shows the standardized structural coefficients. The relative importance of the variables is reflected by the magnitude of the coefficients.

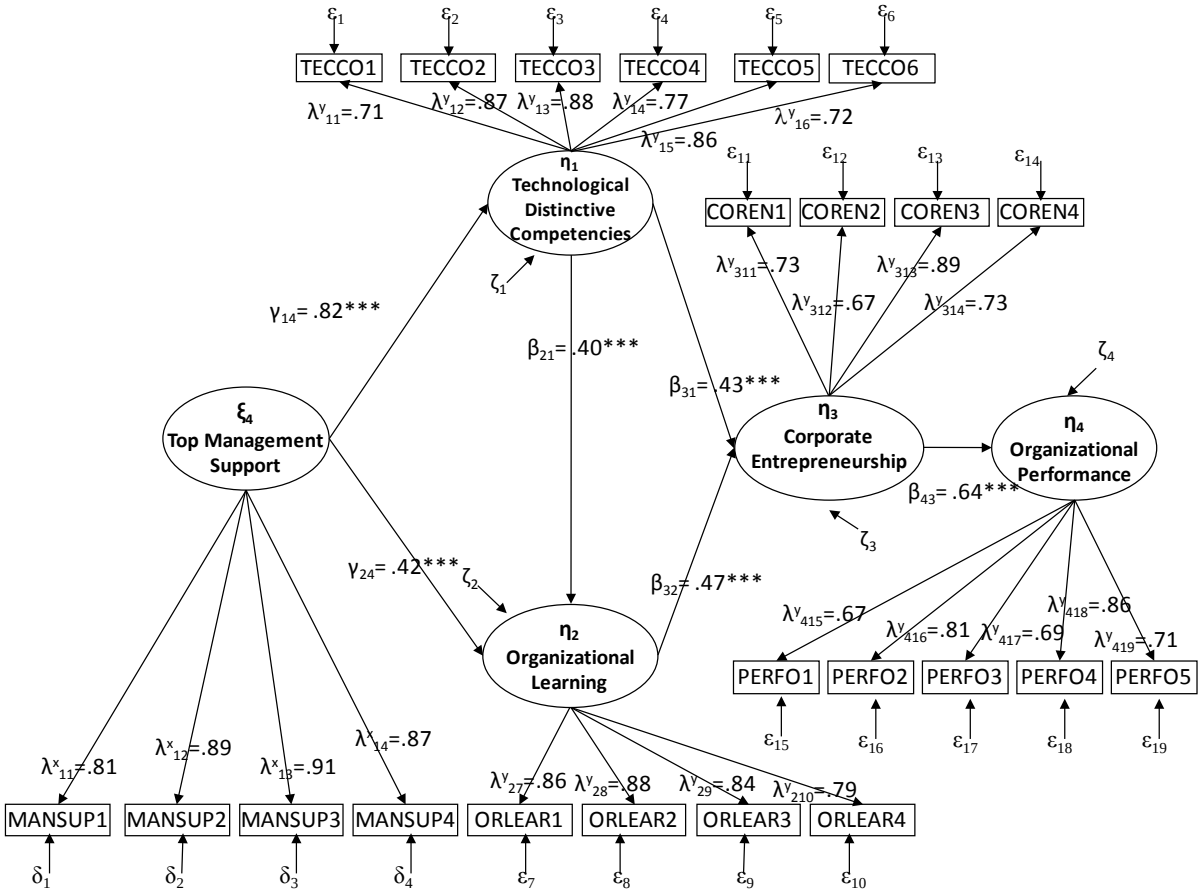

Figure 2*: Results of structural equation model.*

For quality of the measurement model for the sample, the constructs display satisfactory levels of reliability, as indicated by composite reliabilities ranging from 0.84 to 0.92 and shared variance coefficients ranging from 0.57 to 0.87 (Table 4). Convergent validity can be judged by observing both the significance of the factor loadings and the shared variance. The amount of variance shared or captured by a construct should be greater than the amount of measurement error (shared variance>0.50). All of the multi-item constructs meet this criterion, each loading (λ) being significantly related to its underlying factor (t-values>15.55) in support of convergent validity. To assess discriminant validity, we performed a series of chi-square difference tests on the factor correlations among all constructs (Anderson and Gerbing, 1988). We did this for each pair of latent variables by constraining the estimated correlation parameter between them to 1.0 and then performing a chi-square difference test on the values obtained for the constrained and unconstrained models (Anderson and Gerbin, 1988). The resulting significant differences in chi-square indicate that the constructs are not perfectly correlated and that discriminant validity is achieved.

Table 4: Validity, reliability and internal consistency.

Variable	Item	Parameter	Validity, reliability and internal consistency		
			λ*	R^2	A. M.
Top Management Support	MANSUP1	λ^x_{11}	0.81***(f.p.)	0.66	α=0.926 C.R.=0.925 S.V.=0.757
	MANSUP2	λ^x_{12}	0.89***(23.13)	0.79	
	MANSUP3	λ^x_{13}	0.91***(23.28)	0.82	
	MANSUP4	λ^x_{14}	0.87***(22.88)	0.76	
Technological Distinctive Competencies	TECCO1	λ^y_{11}	0.71***(f.p.)	0.50	α=0.917 C.R.=0.916 S.V.=0.877
	TECCO2	λ^y_{12}	0.87***(22.76)	0.76	
	TECCO3	λ^y_{13}	0.88***(22.94)	0.78	
	TECCO4	λ^y_{14}	0.77***(21.63)	0.60	
	TECCO5	λ^y_{15}	0.86***(22.69)	0.73	
	TECCO6	λ^y_{16}	0.72***(21.21)	0.53	
Organizational Learning	ORLEAR1	λ^y_{27}	0.86***(f.p.)	0.74	α=0.908 C.R.=0.906 S.V.=0.708
	ORLEAR2	λ^y_{28}	0.88***(23.17)	0.77	
	ORLEAR3	λ^y_{29}	0.84***(22.87)	0.70	
	ORLEAR4	λ^y_{210}	0.79***(22.44)	0.62	
Corporate Entrepreneurship	COREN1	λ^y_{311}	0.73***(f.p.)	0.54	α=0.867 C.R.=0.849 S.V.=0.588
	COREN2	λ^y_{312}	0.67***(19.61)	0.51	
	COREN3	λ^y_{313}	0.89***(22.04)	0.80	
	COREN4	λ^y_{314}	0.73***(20.43)	0.54	
Organizational Performance	PERFO1	λ^y_{415}	0.67***(f.p.)	0.55	α=0.867 C.R.=0.872 S.V.=0.579
	PERFO2	λ^y_{416}	0.81***(16.59)	0.65	
	PERFO3	λ^y_{417}	0.69***(15.84)	0.51	
	PERFO4	λ^y_{418}	0.86***(16.58)	0.74	
	PERFO5	λ^y_{419}	0.71***(15.55)	0.50	

Note: λ* = Standardized Structural Coefficient; R^2 = Reliability; α = Alpha Cronbach; C. R. = Compound Reliability; S. V. = Shared Variance; f. p. = fixed parameter; A. M. = Adjustment Measurement; *p < .05; ** p < .01; *** p < .001(two-tailed).

The overall fit measures, multiple squared correlation coefficients of the variables (R^2s), and signs and significance levels of the path coefficients all indicate that the model fits the data well (χ^2_{224}=574.86; p>.001; χ^2_{ratio}=2.56; NFI=.99; NNFI=0.99; GFI=.99; CFI=0.99; IFI=.99; PGFI=.80). The hypothesized model was a significantly better fit than the null model (χ^2_{253}=11984.91; p>.001;Δ χ^2_{29}=11410.05;p>.001). All of the modification indices for the beta pathways between major variables were small, suggesting that adding additional paths would not significantly improve the fit. The residuals of the covariances were also small and centred around zero.

If we examine the standardized parameter estimates (Table 5), the findings show that TMS (γ_{11}=.82; p<.001) is related to and affect TDCs, as predicted in Hypotheses 1. TDCs is explained well by the model (R^2=.67). TMS affects the development of TDCs because human, conceptual, and technological competency are thought to be supported by managerial effectiveness (Benitez *et al*., 2010). TMS also affects OL directly (β_{21}=.42; p<.001). Furthermore, we have shown an indirect effect (.33; p<.001) of TMS on OL by TDCs (.82x.40; see Bollen, 1989 for calculation rules). The global influence of TMS on OL is thus 0.75 (p<.001), supporting Hypothesis 2. TMS encourage OL processes´ development, which let new technological abilities and knowledge be developed (García et al., 2006). TDCs affects OL (γ_{21}=.42; p<.001) supporting Hypothesis 3. TDCs allow increasing an organization's capability to carry out actions and improving OL (Senge *et al*., 1994). Comparing the magnitudes of these effects indicates that the effect of TMS on OL is larger than the effect of TDCs on OL. Globally, OL is explained well by the model (R^2=.61).

Corporate entrepreneurship is influenced by TDCs (β_{31}=.43; p<.001) and OL (β_{32}=.47; p<.001), supporting Hypotheses 4 and 5, respectively. Furthermore, we have shown an indirect effect (.19; p<.001) of TDCs on corporate entrepreneurship by OL (.40x.47). The global influence of TDCs on corporate entrepreneurship is thus 0.62 (p<.001). Comparing

the magnitudes of these effects indicates that the total effect of TDCs on corporate entrepreneurship is larger than the total effect of OL on corporate entrepreneurship. Globally, corporate entrepreneurship is explained well by the model (R^2=.71).

TDCs and OL enhance capacity and knowledge to discover and exploit entrepreneurial opportunities (Omerzel and Antoncic, 2008). Finally, for organizational performance, we find a significant relationship with corporate entrepreneurship (β_{43}=.64; p<.001), supporting Hypothesis 6. Corporate entrepreneurship allows increasing the benefits for the companies (Andreu and Ciborra, 1996; Shane and Venkataraman, 2000). Globally, organizational performance is explained well by the model (R^2=.41). In addition to these effects, we have shown other indirect effects in Table 5.

Table 5: Structural Model Result (Direct, Indirect and Total Effects).

Effect from		To	Direct Effects [a]	*t*	Indirect Effects [a]	*t*	Total Effects [a]	*t*
Top Management Support	→	Tech. Dist. Competencies	0.82***	16.34			0.82***	16.34
Top Management Support	→	Organizational Learning	0.42***	4.35	0.33***	4.44	0.75***	16.73
Top Management Support	→	Corporate Entrepreneurship			0.70***	16.59	0.70***	16.59
Top Management Support	→	Organizational Performance			0.45***	14.44	0.45***	14.44
Tech. Dist. Competencies	→	Organizational Learning	0.40***	4.27			0.40***	4.27
Tech. Dist. Competencies	→	Corporate Entrepreneurship	0.43***	6.08	0.19***	3.72	0.62***	8.99
Tech. Dist. Competencies	→	Organizational Performance			0.39***	8.64	0.39***	8.64
Organizational Learning	→	Corporate Entrepreneurship	0.47***	6.08			0.47***	6.08
Organizational Learning	→	Organizational Performance			0.30***	5.96	0.30***	5.96
Corporate Entrepreneurship	→	Organizational Performance	0.64***	16.81			0.64***	16.81
Goodness of Fit Statistics		χ^2_{224}=574.86 (P>0.01) GFI=0.99 AGFI=0.99 ECVI=3.39 AIC=678.86 CAIC=902.63 NFI=0.99 NNFI=0.99 IFI=0.99 PGFI=0.80 NCP=350.86 RFI=0.98 CFI=0.99 RMSEA=0.088						

Notes: [a] Standardized Structural Coefficients; $^{\dagger}p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

In testing the theoretical framework, we fit several nested models, each incorporating different assumptions about parameters. Comparisons with reasonable alternative models are recommended as a means of showing that a hypothesized model is the best representation of the data. Comparison is considered to be an important part of assessing model fit (Bollen and Long, 1993). The summary statistics in Table 6 indicate that Model 1 was preferred to the others, supporting the inclusion of a model with these relationships among the analyzed constructs. For example, if we compare the theoretical model (Model 1) to a model that does not consider the relationship between corporate entrepreneurship and organizational performance (Model 6), we can see that the latter has a worse Root Mean Square Error of Approximation (>RMSEA=.008), Expected Cross-Validation Index (>ECVI=.30), Akaike Information Criterion (>AIC=58.92), Consistent Akaike Information Criterion (>CAIC=58.92) and Estimated Non-Centrality Parameter (>NCP=58.92). Hence, results show that corporate entrepreneurship affects organizational performance and that Model 1 was preferred to Model 6 ($\Delta\chi^2$=58.92;Δdf=1). The theoretical model is also preferable to other models formulated (Table 6). Length restrictions prevent a detailed discussion of each model and of other models (a full report is available from the authors). In sum, the proposed theoretical model represents (Figure 2) the preferred, i.e. the most acceptable and parsimonious, model.

Table 6: Model Statistics against Theoretical Model.

Description	χ^2	*df*	$\Delta\chi^2$	RMSEA	ECVI	AIC	NCP	CAIC
Theoretical	574.86	224		0.088	3.39	678.86	350.86	902.63
W.R. Top Man. Support→Org. Learning	599.64	225	24.78	0.091	3.51	701.64	374.64	921.10
W.R. Tech. Dist. Competencies→Org. Learning	590.80	225	15.94	0.090	3.46	692.89	365.89	912.36
W.R. Tech. Dist. Competencies→Corp. Entrepreneurship	606.92	225	32.06	0.092	3.54	708.69	381.69	928.16
W.R. Org. Learning→Corp. Entrepreneurship	627.01	225	52.15	0.095	3.65	729.01	402.01	948.48
W.R. Corp. Entrepreneurship→Org. Performance	633.78	225	58.92	0.096	3.69	737.78	409.78	961.55

Notes: W.R.=Without Relationship; n=201

CONCLUSIONS AND FUTURE RESEARCH

Discussion

Research´s results have supported the existence of a positive significant relationship between TMS and TDC. TDCs development will be enable if the top managers achieve some fundings y support their development. This support does not have to be only financial support (Petroni and Panciroli, 2002); it must also be educational support, as all the employees in the company should trained to understand and achieve the distinctive competencies on technology (Andreu and Ciborra, 1996; Haro et al., 2010; Leonard-Barton and Deschamps, 1988; Torkkeli and Tuominen, 2001). TMS is also significant positively related to OL. Top managers should motivate learning processes and promote some courses for the employees and lower managers to learn all the knowledge generated by technological competencies in order to become an intelligent organization difficult to imitate (Leonard-Barton, 1992; Lloréns *et al*., 2005). Likewise, the results of the research support that TDC encourage OL. This learning must be produced in all organizational levels in order to achieve excellent technological skills and a specific technological knowledge (Lee *et al*., 2001).

When TDCs and OL are promoted in the firm, some opportunities appear for entrepreneurs in the firm (Woolley, 2010). If technological organizations use their capacity to absolve new technology, or their capacity to generate new advanced technological processes, they will exploit their TDCs and may obtain an outstanding advantage over other firms (Real *et al*., 2006). Likewise, it is shown how corporate entrepreneurship is also promoted by OL, since the higher new knowledge acquired in the organization will increase the autonomy of different parts in the firm, what will allow it to adopt more flexible structures to increase their corporate entrepreneurship and it will also let employees be more creative (Antoncic and Hisrich, 2001; García *et al*., 2006; Knight, 1997). Finally, the results show up that corporate entrepreneurship will increase the benefits in the firm, sales or the market share (Antoncic and Prodan, 2008; Lengnick-Hall, 1992; Murray and Kotabe, 1999). Corporate entrepreneurship is beneficial to the revitalization and performance of large corporations, as well as that of small and medium enterprises (Antoncic and Hisrich, 2001). Organizations that engage in entrepreneurial activities achieve higher levels of growth and profitability than organizations that do not (Antoncic and Hisrich, 2001), thereby obtaining higher performance (Antoncic and Prodan, 2008; Zahra, 1993).

Limitations and future research

The investigation presented exhibits several limitations. First, survey data based on self-reports may be subject to social desirability bias (Podsakoff and Organ, 1986). However, an assurance of anonymity can reduce such bias even when responses are related to sensitive topics (Konrad and Linnehan, 1995). The low risk of social desirability bias in this study was indicated by several managers who commented that it made no sense at all for their companies to go beyond regulatory compliance. Still, the responses are subject to interpretation by individual managers.

Second, the use of the CEOs to responded questions on TMS or corporate entrepreneurship. are valid measures (e.g., García et al., 2008), however, interviewing and administering questionnaires to other organizational members would have been preferable to verify these variables. To confirm the validity provided by the CEO in the research we sent the same questions to members of selected firms. The different results were contrasted with those obtained in the main research survey by means of different tests to confirm that there were no significant differences between the research variables.

Third, although Harman's one-factor test and other method tests did not identify common method variance as a problem, it still might have been (Podsakoff and Organ, 1986; Konrad and Linnehan, 1995). Although Spector (2006) has argued that it is incorrect to assume that the use of a single method automatically introduces systematic bias, we recommend that future research gather measures of independent and dependent variables from different data sources to minimize the effects of any response bias (Podsakoff *et al*., 2003).

Fourth, our data are cross-sectional, making it difficult to examine the evolution of the different variables in our study. This aspect is of particular interest when considering the dynamic nature of some of our variables. Although we tested the most plausible directions for the pathways in our model, longitudinal research is needed to assess the direction of causality of the relationship and to detect possible reciprocal processes. We have tried to temper this limitation through attention to theoretical arguments by rationalizing the relationships analyzed and integrating temporal considerations into measurement of the variables (Hair *et al*., 1999). Fifth, future studies should be based on a larger sample and preferably in more than one country. As this study focuses only on Spanish firms, an empirical research paper could study the same relationship in Europe in order to generalize the results throughout the European economy, and subsequently throughout the world.

Finally, the model only analyzes the relation of TDCs (influenced by TMS), TMS and OL on organizational performance through corporate entrepreneurship. It should be noted that the variables selected explain an acceptable amount of the variance in organizational performance. However, other intermediate constructs could be analyzed, such as absorptive capacity or knowledge management (e.g., García *et al*., 2006; Nonaka and Takeuchi, 1995). The homogeneous geographical context examined here, limits the influence of external factors, but future research might well explicitly integrate the influences of external factors.

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APPENDIX.

- **Top Management Support.**

1. Indicate the degree to which you agree or disagree with the following statements about top management support.
   1.1. Top management cultivates technology project champions.
   1.2 Top management ensures adequate funding of technology research and development.
   1.3 Top management restructures work processes to leverage technology opportunities in the organization.
   1.4 Top management facilitates technology transfer throughout the organization.

- **Technological Distinctive Competencies.**

2. Indicate the degree to which you agree or disagree with the following statements about whether the organization has:
   2.1 Capability to obtain information about the status and the progress of science and relevant technologies.
   2.2Capability to generate advanced technological processes.
   2.3 Capability to assimilate new technologies and useful innovations.
   2.4 Capability to attract and retain its qualified scientific-technical staff.
   2.5 Capability to dominate, generate or absorb basic and key technologies of business.
   2.6 Capability to establish efficient programs to develop technology from R&D units, providers and clients.

- **Organizational Learning.**

3. In the last three years:
   3.1 The organization has acquired and shared much new and relevant knowledge that provided competitive advantage.
   3.2 The organization's members have acquired some critical capacities and skills that provided competitive advantage.
   3.3 Organizational improvements have been influenced fundamentally by new knowledge entering the organization (knowledge used).
   3.4 The organization is a learning organization.

- **Corporate Entrepreneurship.**

4. In the last three years.
   4.1. Proactiveness.
      4.1.1. In dealing with competitors, the organization is very often the first business to introduce new products/services, administrative techniques, operating technologies, etc.
      4.1.2. In dealing with competitors, our organization typically adopts a very competitive, undo-the-competitors posture.
      4.1.3. In general, the top managers at our firm have a strong proclivity for high risk

projects (with chances of very high returns).

4.1.4. In general, the top managers at our firm believe that, owing to the nature of the environment, bold, wide-ranging acts are necessary to achieve the firm's objectives.

4.1.5. When confronted with decision-making situations involving uncertainty, our organization typically adopts a bold, aggressive posture in order to maximize the probability of exploiting potential opportunities.

4.2. New business venturing.

4.2.1. The organization has stimulated new demands on the existing products/services in the currents markets through aggressive advertising and marketing.

4.2.2. The organization has broadened the business lines in the current industries.

4.2.3. The organization has pursued new businesses in new industries that are related to the current business.

4.2.4. The organization has found new niches for the products/services in the current markets.

4.2.5. The organization has entered new businesses by offering new lines and products/services.

4.3. Self-renewal.

4.3.1. The organization has revised the business concept.

4.3.2. The organization has redefined the industries in which the company will compete.

4.3.3. The organization has reorganized units and divisions to increase organizational innovation.

4.3.4. The organization has coordinated activities among units to enhance organizational innovation.

4.3.5. The organization has increased the autonomy (independence) of different units to enhance their innovation.

4.3.6. The organization has adopted flexible organizational structures to increase innovation.

4.3.7. The organization has rewarded employees for creativity and innovation.

4.3.8. The organization has trained and encouraged to the employees to be creative and innovative.

4.9. Organizational innovation.

4.9.1. The organization has significantly increased:

4.9.2. The emphasis on developing new products/services.

4.9.3. The rate of new products/services introduction into the market.

4.9.4. The spending on new products/services development activities.

4.9.5. The number of products/services added by the organization and already existing in the market.

4.9.6. The number of new products/services introduced for first time in the market by the organization.

4.9.7. Percentage of revenue generated from new businesses/services that did not exist three years ago.

- **Organizational Performance.**

5. Relative to your main competitors, what is your firm's performance in the last three years in the following areas?

5.1. Organizational performance measured by return on assets (economic profitability or ROA).

5.2. Organizational performance measured by return on equity (financial profitability or ROE).

5.3. Organizational performance measured by return on sales (percentage of profits over billing volume).

5.4. Organization's market share in its main products and markets.

5.5. Growth of sales in its main products and markets.

THE ADOPTION OF AMERICAN HURMAN RESOURCE MANAGEMENT AMONG JAPANESE SUBSIDAIRES IN MALAYSIA: MYTH OR REALITY?

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ABSTRACT

The success of Japanese firms in the 1980s has often been associated with their unique HRM model. However with the recent global recession, many firms in Japan are abandoning their traditional HRM model. Japanese firms are now seeking the Western HRM, and in particularly the American model as their source of inspiration. Although they have been a lot of related articles on the success of Japanese style HRM, only a handful articles are available on the end of the Japanese style HRM. Moreover, the articles are often limited from the context of Japanese firms operating in Japan. In relation to the end of the Japanese HRM abroad and the emergence of 'dominance effect' theory, research findings are even limited. Hence, we hope to close the cross-national gap by adopting a multiple-case study approach that addresses on the HRM practices of 5 Japanese subsidiaries in Malaysia in view of the recent economy crisis. Among the major HRM practices examined are remuneration systems, training and development and employment policies and practices. In particularly, the study examined whether there is a possibility of convergence towards the American model among the subsidiaries. General findings appear that some HRM practices does resemble the American model. The study is perhaps one of the first to address the HRM practices from the viewpoint of key people such as CEO, Managing Director and Human Resource Director.

Keywords: Japan, Human Resource Malaysia, Malaysia, Dominance

INTRODUCTION

The ongoing global recession in 2009 has a major impact on emerging markets like Malaysia. The sales value of the manufacturing sector in 2009 decreased 25.5% or RM13.5 billion as compared to RM52.7 billion in June 2008 (Department of Statistic Malaysia, 2009). At the same time, employment rate in the country was also reported to be at 3.6 percent which is 0.1 percent higher when compared to 2008. The Malaysia's GDP growth rate remains sluggish and even at a point turns negative at 3.9% per cent in 2009 (Department of Statistic Malaysia, 2009). The decrease was a result of a falling global demand from the United States which is one of the major consumer markets in the world. With unemployment rate in the United States forecasted to be above 10 per cent in 2009 (STAR, 2009), many firms are reorienting their

corporate strategy in respond to the recession. Griffin and Smith (2010) explained that some organizations reacts to the recession by cutting training budgets, freezing recruitment and omitting redundancies. Regardless of the strategy, the ongoing downturn has indeed resulted in global pressure on foreign firms in overseas such as the Japanese firms in Malaysia. Due to the pressure from the drop in global demand, companies have to re-balance their resources well and one key area of resources is the human capital in the firm. Thus it is likely that their Human Resource Management (HRM) policies may need to be modified and tailored to the current challenging economic scenario.

In this time of uncertainly, many Japanese firms are also abandoning or modifying their traditional HRM practices. Large Japanese firms and public administration in Japan are moving away from their traditional HRM practices (McCune, 1990; Morishima, 1995; Hircomichi, 2000; Masabumi, 2005). Japanese HRM model are no longer view by the Japanese employers as the critical success factor as they are not flexible. The once 'key success factors' has now becomes a burden and to some extend was regarded as a 'key failure factors' (Maanen, 2006). Unlike in the 1980s, the once celebrated Japanese HRM is now even viewed negatively by both the American and German HR experts (Pudelko, 2004). Instead, the Japanese firms are now seeking the Western HRM model as their source of inspiration (Pudelko & Mendenhall, 2007; Miles 2007). Interestingly, the American model is viewed as the best model to adopt in this challenging environment (Muller, 1999; Edward et al., 2005). This is because the model represents modernity and the future (Smith & Miksins, 1995). Similar sentiment was echoed by Pudelko (2004) in which the American model was viewed previously with skepticism are now viewed positively than ever by the Japanese HR experts. The finding was also supported by Masabumi (2005) and Chaudhuri (2010) in which the Japanese HRM styles in Japan are indeed leaning towards the American HRM. Pudelko and Harzings (2007) further explained that the emergence of the American model is the result of 'dominance effect' which is based on highly competitive national model of best practices. They further explained that the model neither follows the localization nor the country-of-origin effect, but instead the pole is headed towards the nation that sets the standards as the global best practices and in this case, the United States of America.

RESEARCH OBJECTIVE

The literature reviews of Japanese HRM is in crisis and the emergence of 'dominance effect' in the convergence theory seems to suggest that the Japanese HRM model has lost its appeal and is widely believed to be heading into a declining stage. This has lead us to trying to understand if this pattern also occurs for most of the Japanese subsidiaries abroad and in this case in Malaysia. We also seek to understand how Japanese firms abroad are responding to the recent crisis especially from the HRM perspective and whether this impact will lead to a transformation to a more American Model. In this context of the study, Malaysia which plays host to Japanese firms since the 1980s is a good base to examine on the above mentioned theory. Firstly, there are more than 3000 multinational enterprise in Malaysia and out of the 3000 organizations, Japanese firms has the highest number at 18.5 percent (Sambasivan and Jacob, 2008). Moreover Japan has been Malaysia top three investors since year 2000 and their

Foreign Direct Investments (FDI) has surpassed the United States and other Western nations in 2006 and 2007 with RM1,195 millions and RM6,129 millions respectively (Embassy of Japan, Malaysia, 2008). While empirical evidence exists on the uniqueness of the Japanese HRM as the secret of success (Ouchi, 1981; Fukuda, 1988; Jenkins and Florida, 1999; Masabumi, 2005) only a handful articles are available on the end of the Japanese HRM (McCune, 1990; Harada, 1999; Pudelko & Mendenhall, 2007). The articles however are also limited to the context of Japanese firms operating in Japan. While, in relation to the end of the Japanese HRM and the emergence of 'dominance effect' on and towards the Japanese subsidiaries abroad, research findings are even more limited, let alone any. The little empirical work is surprising as Japan is regarded as one of the biggest investors in the world and thus without the view of cross-national adaption, there seems to be a missing gap in the understanding of Japanese management. Our papers plan to address the missing gaps by attempting to answer to the following questions. In view of the perception that Japanese HRM is in crisis and the emergence of 'dominance effect, are the Malaysia Japanese subsidiaries orientating themselves towards the American HRM model as the best practices as the result of this recession? If so what are the changes in the HRM functions as a result of this recession? Secondly, what are some of the perceptions and views of HR Managers on the Japanese HRM practices in Malaysia in the coming years? Is Japanese HRM outdated? What are some of the Japanese HRM elements they wish to retain and change?

The research paper is important at least for three reasons. Firstly, the research is important as it helps to understand the survivability of Japanese HRM in Malaysia in the coming years. Secondly, the result can also help to explain and predict the HRM patterns of other Japanese subsidiaries abroad such as in Indonesia, Thailand, Singapore, etc. The findings also serve as valuable information to foreign companies which are competing against the Japanese firms. Lastly, the research will also help to shed lights on the HRM strategies and behavior for most of the overseas Japanese firms as the result of the crisis in which we believed there will be a lesson learnt. The article is structured as follows. First we provide an overview of the current literature of Japanese HRM and the debates between home country and host country practices. This is followed by the research methodology and the findings and discussion. Finally we present the conclusion and as well as the implications and limitation for future studies.

LITERATURE REVIEW

The End of Japanese HRM Practices

One of the key factors in the rise of most Japanese firms from the early 1970s to the early 1980s is attributed to their unique Japanese HRM (Ouchi 1981; Amante, 1993; Jenkis and Florida 1999). Masabumi, (2005) accredited the success to the 'three scared treasures' of HRM, which is the lifetime employment, seniority systems and company-based union. The combination of the 'three sacred treasures' improved productivity and led to stronger employee identification within the organization (Moore, 1987). However since early 1986, the Japanese economy has been facing with constant challenges. The rise in the exchange value of Japanese Yen in 1987, has lead Japan to lose their comparative advantages. Exports became too expensive in anticipating of the rise of labour cost. Jain (1987) explained that the

unemployment rate for the first time even jumped to about three percent and there was a fall of 1.9 percent in the manufacturing sector in 1994 (Ministry of Labour, 1996). The Japanese economy continues to remain sluggish and at a point even turn negative during the Asian fiscal crisis (Porter & Takeuchi, 2000). Orders fell and many Japanese organizations were badly affected (Benson and Debroux, 2004). In order to survive, many Japanese organizations decided to transfer their manufacturing firms abroad and many employers were compelled to retire early (Miles, 2007). Similarly, Japan also underwent a painful restructuring and business difficulties in 2008 as a result of the global recession. In view of the disappointing economy, Japan continues to face with strings of challenges from both the domestic and overseas markets (Takeuchi, 2009). In the wake of this long recession and disappointing economic performance, scholars have begun to call for reforms (Dore 1999; McCormick, 2004). The traditional Japanese HRM practices are now viewed as outdated and no longer important in today's reality (Smith, 1997; Crawford, 1998; Pudelko 2005). Ornatowski (1998) called for the end of the Japanese HRM. Stiles (2009) on the other hand, linked the Japanese HRM to as 'Japanese disease'. Dalton and Benson (2002) concluded that the 'traditional' Japanese HRM model is in crisis and is subject to major change. Similarly, Lonien (2003) concluded that the three pillars of the Japanese model are in the midst of collapse and were forecasted to be replaced with the Western management model soon. Thus in order to survive many Japanese firms are abandoning or modifying their traditional management practices (Benson and Debroux, 2004; Miles 2007; Takeucho, 2009).

Large Japanese companies and public administration are indeed moving away from their traditional HRM practices (McCune, 1990; Morishima, 1995; Hiromichi, 2000). The changes has taken place not only in large international firms such Sony, Matsushita Electrics, Toyota, Canon, Yamaha, Hitachi and Mitsubishi but also within small Japanese organizations (Sanchanta 2002; Economist, 2007). In order to minimize cost, many Japanese organizations have begun to abandon the lifetime employment system (Masabumi, 2005; Stiles, 2009). Lonien (2003) shed lights by providing evidence that only 10 percent of Japanese domestic firms are still practicing the system in 1999 unlike at 27% in 1990. Furthermore, Sony Corporation has also recently announced its desired to reduce 10,000 positions worldwide in March 2008 with 40 percent alone in Japan (Worthleya et al., 2009). Thus this seems to suggest that the lifetime employment (Abegglen, 1958) may not be as important as previously. The lifetime employment is gradually being replaced with the individuated 'lifetime employability' perspective (Brislin, MacNab and Worthley 2005) and contract employment (Benson and Debroux, 2003). The traditional recruitment style are also seems to be moving away due to the changes in the lifetime employment. The practices now appear to be more flexible (Benson and Debroux, 2004). More Japanese companies are allowing for the entry of new and experience employees throughout the year rather than in spring (Bamber, and Shadur, 1992). The hiring of inexperienced graduates from elite universities was also being called into questions as more companies are now hiring white-collar technical workers without a college degree (Salmer, 2001). Seiko-Epson Corp recently had broken away traditional hiring process by recruiting 100 'mid-term' employees from other companies (McCune, 1990). Large companies are also trimming down on the recruitment of new graduates while giving emphasis to candidates who are immediately operational such as the unemployed workers (Ogashi, 2006). Similarly, finding

from scholars also indicated that more companies are now recruiting specialist while less emphasis has been given on generalist workers (Pudelko and Mendenhall, 2007). The new characteristic of the Japanese recruitment style resemble to three new patterns namely the 'multi-stream employment patterns', 'multi-stream recruitment' and an 'intermediate labour market' (Masabumi, 2005). The remuneration and promotion which was based on seniority are also currently losing its significance. They are currently being replaced with merit performance (Ornatowski, 1998; Hiromichi 2000; Salmer, 2001; McCormick, 2004; Morris, Hassard & McCann,2006; Pudelko and Mendenhall, 2007; Takeuchi, 2009). The increased movement towards promotion-for-performance schemes was largely due to the introduction of management-by-objective (MBO) (Morishima, 1995; Chaudhuri, 2010). As such younger employees are now being promoted over their elder employees (Benson and Debroux, 2003). Evidences from RIALS (2002) indicate that there are differences in the manager's salary of large Japanese organizations. Consistent with the changes towards the merit performance, corporate welfare programs, corporate pensions, and retirement pay-outs of the particular employees is also dependable on the employee's performance (Ogashi, 2006). The across-the-board pay increases has also been offset by the variances of bonuses among employees (Ministry of Health, Labour, and Welfare, 2002). Unlike before, Japanese organizations are also creating dual career paths for specialist and generalist (Sethi et al., 1984; Kubo & Saka, 2002; Beson and Debroux 2004). Similar statements were made by Bamber and Shadur, (1992) in which there are evidences pointing to the mixture of managerial and specialist stream with the combination of managerial and professional/specialist/functional strata in some Japanese organizations.

Home Country versus Host Country Debate

Many scholars have attempted to shed lights whether the HRM practices of multinational firms overseas will resemble the home country or the host country practices. Many Japanese parent organizations believe that their operating systems are the source of their competitive advantages and therefore they transfer the practice to their foreign affiliates (Roger and Wong, 1998). As HRM plays a vital role in the implementation of strategy for most multinationals (Lorange and Murphy 1984) failure to transfer HRM effectively between business elements and across national settings will significantly jeopardize the longer term strategic success of the Japanese overseas affiliates (Edstrom and Lorange, 1984). Thus in order to stay efficient, most multinational parent company may push for the adoption of HRM policies which resemble the headquarters' value and culture (DiMaggio and Powell, 1983), resulting the overseas subsidiaries practices to resemble more of the home country practices than the host country practices (Pudelko and Harzing, 2007). On the other hand, in order to encourage mobility of managerial staff between overseas subsidiaries and multinational enterprise, a standardized corporate HRM practices are important as it promotes 'internal consistency'(Evans and Lorange, 1989). Hence, local affiliate HRM practices are molded by the pressure for internal consistency (Rosenzweig and Nohria, 1994) and the overseas subsidiaries practices will likely again to resemble to the home country practices. However, a host country pattern may also appear when the national cultural and institutional characteristic restricts the transfer of HRM practices abroad (Shuler and Rogovsky, 1998; Myloni et al., 2004). Similar sentiments was

endorsed by Hofstede and Bond (1988), Awasthi, Chow & Wu (2001), Zhu, Warner and Rowley (2007) in which HRM in the Asia pacific is influenced by the national institutions, state policy on industrial relations and culture. As such the multinational organizations will adopt to the practices of host country. Hofstede (1983) demonstrated that differences in national cultures vary substantially. A classification of culture index was developed to represent the culture dimensions of each national culture distance. They are the power distance index, individualism and collectivism in the society, masculinity, uncertainty avoidance and Confucianism/Dynamism. As the consequences of the differences in the dimensions across different countries, there is a barrier in transferring HRM practices (Dore, 1973). This is because organization practices are the result of the national culture (Abegglen 1958; Vogel, 1979). For example, Japanese is said to have high collectivism index, which rewards group achievements (Hosftede, 1997) while Malaysian is regarded to have a high individualism index (Lim, 2001), thus individual rewards is more important. In view of the differences between the homogeneous, collectively eastern countries and heterogeneous and individually oriented society (Hofstede, 1983) it is therefore impossible to transfer practices between the two countries (Beechler and Yang, 1994). Similar sentiments were echoed by Kenny and Florida (1993) where the transfer of Japanese managerial practices to the United States was hampered due to the differences of national culture (Abo, 1994). Finally, institutional characteristics such as labour market conditions, social-political environment and unionization (Brewster, 1995; Jackson and Schuler, 1995) can also influence the transfer of HRM practices to the overseas firms thus resulting to the subsidiaries resembling to the host country practices.

The Dominance Effect

The current debate between home country versus host country mainly focuses on the country-of-origin and localization's effect. However there is a new study that focuses on a different pole of dimension. Pudelko and Harzings (2007) concluded this new dimension as the 'dominance effect' model which is based on a highly competitive national model of best practices. Thus, the model acts as a role model for other nations to follow. Takeuchi (2009) explained that the model is applicable to any type of organizations and will result to economics benefits for organizations that adopt to such best practices. In the dominance model the management practices of an organization will neither resemble the country-of-origin nor the localization effect but according to the best practices model (Smith and Meiksins, 1995; Pudelko and Harzings, 2007; Takeuchi, 2009). However, the exact to which country the model follows differs according to time and economic performance. The model resemble closely to the American model from the 1950s to 1960s (Keer et al., 1962). However from the late 1970s to the early 1990s the model appears to resemble to the Japanese model (Oliver and Wilkinson, 1992).

The recession in the Japanese economy in the last decade has encouraged Japanese organizations to shift their attention to Western management practices (El Kahal, 2001; Matanle, 2003). In fact, many Japanese organizations are already converging their HRM practices towards a 'universalist' approach and this approach will continue to follow the best practices from worldwide (Mroczkowski and Hanaoka 1998). Summarizing the findings from the Japan Federation Employer's Association, Takeuchi (2009) concluded that many Japanese

organizations are attempting to inject Western ideas into the old fashion Japanese management system. Masabumi (2005) explained that that the move to 'autonomous worker' management was unavoidable in view of the threats from emerging markets such as China. American HRM practices are now suggested as the 'role model' (Edwards et al., 2005) for most of the Japanese companies in Japan to follow in order to regain its competitiveness (Pudelko and Mendenhall, 2007; Pudelko, 2009). Pudelko and Harzing (2010) shed lights by concluding that that the Japanese subsidiaries in the United States increasingly resemble the local practices. In one of the survey conducted, most Japanese interviewees unanimously concluded that their organizations should be orienting towards the Anglo-Saxon model (Pudelko, 2009). One important aspect of the American HRM is the concept of 'individual work' in which 'ability is equal to work and is also equal to wages' (Tokoro, 1992). The American HRM was seen naturally as a potential solution for Japanese companies to compete globally due to its ability to create competitive advantages among the Japanese firms (Takeuchi, 2009). The findings form Pudelko and Mandenhall (2007) was not surprising as organizations outside the US are already adopting to the 'best HRM practices' from the United States (Zhu, Warner and Rowley, 2007). Take for example, the flexibility to hire and fire, the freedom to downsize and retrench employees, individualized career development system, merit performance evaluation for promotion and welfare (Zhu, Warner and Rowley, 2007). The best practices will resemble closely to the American multinationals due to three important reasons (Smith and Meiksins, 1995). Firstly, this is due to the dominance of American business schools which has been aggressively spreading new frontier of knowledge. Secondly the American consultancies play an important role in disseminating management knowledge worldwide. Lastly this is due to the strengths of the American economy and their multinationals company.

RESEARCH METHODOLOGY

Although the study on the end of Japanese HRM has received a widespread of attention recently, much of the research predominant focuses at the macro view. Thus previous studies may not have gained a true picture necessary to explain on the HRM changes. In this case, we hope to readdress this research gap by adopting a detailed case analysis. In addition, we have decided to adopt the qualitative method because the qualitative method provides an epistemological position (Bryman and Bell, 2003) especially when addressing to questions such as 'how' and 'why (Yin, 1984). Thus this helps to provide a better explanation and addresses to the research objectives in a clearer manner. The sampling for our research paper is adopted from the Federation of Malaysian Manufacturer (FMM) directory. The FMM which was established in 1968 includes more than 2200 manufacturing and industrial service firms in Malaysia (FMM, 2010). We decided to focus our study in the state of Perak, Malaysia which has received a fair attention of Japanese investment in the recent years. Within the different Japanese subsidiaries in the state of Perak, first the Japanese subsidiaries are divided according to the industries. In view of our project timeline, we decided only to focus on a few industry and they are the firebrick, electric and electronic and woodwork industry. According to Kuruvilla, Frenkel and Peetz (2003), the diffusion of HRM practices varies by industries rather than countries. Thus the different industry will provide varieties to this case study. Three requirements were subsequently added. They are as follow (1). Wholly owned Japanese-owned

organizations. According to Purcell et al., (1999), Japanese subsidiaries with majority Japanese shareholders are likely to adopt to Japanese style management when compared to a minority Japanese shareholders. The criterion is important as we do not want the HRM practices to overly resemble to the local practices which would seriously jeopardize our study. (2). Have more than 100 employees in their operation. According to Beamish and Inkpen (1998), subsidiaries with less than 50 employees are usually agency or sales subsidiaries. (3). More than 15 years in operation. The study deliberately chooses to only consider subsidiaries operating more than 15 years so that any HRM practices can be clearly reflected by the timeline. Stratified sampling was then applied to obtain random samples, thus leading us to the five subsidiaries of study. The data used in this case study were obtained through intensive interviews all conducted between May 2010 to January 2011. We decided to adopt a semi-structured style, as it allows us the flexibility to vary the sequence of the questions and moreover the interview style reduced the amount of missing data (McKnight et al., 2007) in the quantitative study. The HRM practices examined are such as remuneration systems, training and development and employment policies and practices. The practices above are considered to be the most extensively used practices in most HR literatures (Lewis, 2003). The interview questions were addressed to key personal of the organizations such as Chief Executive Officer, Managing Director, Human Resource Director, Human Resource Manager, Factory Manager, First-line supervisor, Japanese expatriate and employees. The Chief Executive Officer, Managing Director and Human Resource Director were chosen because they are assume to know the hidden information regarding the HRM directions of the subsidiary and the ability to understand the Japanese and American HRM practices more than the other employees within the firm, whereas the local Human Resource Manager and Factory Manager are assume to know more about the implementation and operation of the HRM policies within each departments. Furthermore the changes of the policy at the top levels does not give change to the day-to-day strategies of the bottom level, thus the view of the first-line supervisors are equally important. The information provided by the employees on the other hand serves as a triangulation method to verify and ensure reliability of information collected. The numbers interviews conducted in total within the 5 subsidiaries are 1 Chief Executive Officer, 4 Managing Directors, 2 Human Resource Directors, 3 Human Resource Managers, 3 Factory Managers, 4 First-line Supervisors, 2 Japanese expatriates and 16 employees. Interviews generally took about one-to-two hours per session to complete. The data was recorded and transcribed subsequently. In line with most of the case study approaches, the study shall give priority to 'voices' of the respondents. This is important as their voices provide a genuine mood of the dilemmas, process and strategies faced especially during the economy crisis. For this research, we have also adopted the following research methods such as gathering other unpublished data such as the HRM policies, brochures, site-visit and website information. In view that most of the respondents were able to speak in fluent English, the interviews were conducted in English apart from the two Japanese expatriates where the study engaged the help of a translator. In terms of drawing the conclusion, the study adopts the bipolar dimensions. By drawing contrast between two different practices e.g. American practices versus the Japanese practices (e.g., performance based as opposed to seniority based; specialist training as opposed to widespread training; individual achievements as opposed to collective achievements) we

were able to characterize whether the subsidiaries HRM practices fall between localization, country-of-origin or hybridization.

Overview of the Japanese Subsidiaries

In order to maintain the anonymity of the subsidiaries of study, the subsidiaries are not written as firm-specific but in general names such as Company A, B, C, D and E.

Case 1: Insulating Firebrick Firm

The first business setting studied for the first case (referred to as 'A') is a 100% Japanese-owned subsidiary with a presence in Japan, Korea, Singapore, Taiwan, China and Germany. The parent company which is a public listed company in Japan was established in 1927. In Malaysia, the company was established in Chemor, Perak in 1990 with RM24 million paid up capital. Apart from the factory in Chemor, the company also has another sister division in Johor, Malaysia. The company is one of the leader in producing insulating firebricks and serves major industries such as petrochemical, ceramics, iron and steel within Japan and abroad such as in Australia, China, Japan, Singapore, South Africa, South Korea, Taiwan, United Kingdom, Thailand and Indonesia. The company currently has staff strength of 250 employees.

Case 2: Electric and Electronic Firm

In the second case, the business setting studied concerns a Japanese-owned subsidiary with presence in Singapore, Thailand, Hong Kong, China, Taiwan, Japan and the United States. The company shall be referred to as 'B'. The company has been incorporated since 1993 with over 90 percent investments from Japan. Likewise, the company is also located in Perak has over 700 employees under its wing. Among the products manufactured are such as Fixed Fusible Resistors, Hybrid LC, Fixed Carbon Composition Resistors and etc. The products are mainly exported to Japan with key buyers such as Sony Group, Toshiba, NEC, Fujitsu, Canon, Aiwa, Alcatel, Thomson, Siemens, Motorola, Compaq, Mitsubishi Groups, Sharp Groups, Apple, Philips and Ford.

Case 3: Electric and Electronic Firm

The company in the third case studied is referred hereto as 'C'. It was incorporated in 1993 with a paid up capital of RM6 millions. The business unit belongs to a Japanese organization of a multinational enterprise and is located in the Perak region. Among products produced are such as ceramic electronics components and advanced electronic materials such as thermostat and onboard sensor and mostly are for both local and export markets. The company at the moment has a total workforce of 440 employees.

Case 4: Woodwork Firm

The company in the fourth case studied, was established in 1993 as a manufacturer of coffee table parts. The company shall be referred to as 'D'. Since then they have been diversifying their business and currently also produce furniture for bedrooms and living gardens. Among the products manufactured are premium quality tables, beds and chairs. Most of the products are however not for local sales and only exclusively for the Japanese market. The company likewise is also located in the heart of Perak. The company has a total of 250 employees as at 2011. There are 5 Japanese managers, two managers in the production area, one in the human resource area and 2 managing directors that serve as a liaison role between the company's parent company and subsidiary.

Case 5: Woodwork Firm

The company in the last case studied, was established in 1994 with over 90 percent of investment from Japan. The company shall be referred as 'E'. The company produces wooden component parts and builders joineries. The company has regional offices and presence in all South East Asia countries. Unlike company D the products manufactured by the company are distributed to local furniture suppliers in Malaysia and also exported abroad. In view of the rapid progress and growth, the company has been able to transform into a holding company with three more additional subsidiaries under its belt. At this very moment, the company has approximately 600 employees.

FINDINGS

Employment Policies and Practices: Staffing Practices

The Japanese subsidiaries HRM policy resembles the hybridization model previously. In view of the recession, the policy has changed and stricter rules were introduced. The practices now resemble the American HRM. Unsatisfactory work performance and misconduct would lead to termination and even job downgrading. Similarly, upon retirement, previously employees were allowed to continue their employment on a yearly contract basis. However, this has been abolished during recession to save cost. Below are statements made by the Chief Executive Officer and the Managing Director;

Company A: 'Previously, if the employee fails to perform, we will issue him/her with 1st, 2nd and 3rd warnings. Again, if the employee is still not able to perform, we will repeat the warnings to 1st, 2nd and 3rd. We have no intention to sack the employee. However, in view of the global meltdown, we are stricter. Upon the 1st third warning, we will immediately issue the employee with a termination letter. In response to the retirement policy, previously employees were allowed to work beyond 56 years old with a yearly contract and 30 percent reduction in salary. However, this practice was abolished during the recession.' (Managing Director)

Company B: 'Yes, we are certainly more aggressive and demanding during the recession. If the employee is not able to perform, we will not hesitate to take disciplinary action or to transfer the employee to another department. As for the policy after retirement, previously the employees were allowed to continue working on a yearly contract with 30 percent reduction in salary subject to the management approval, but this has also been abolished.' (Managing Director)

Company D: 'Previously we will do counseling and only issue the employee with verbal warnings. However now we issue the employee with warning letters. We have also recently downgraded an employee in which we have never done it before. As regards to work policy after retirement, previously most of the white-collar employees were allowed to work after the retirement age. Our practices were slightly similar to the practices in Japan but not common among the local firms in Malaysia. However, we have abolished the practice during the recession to save cost.' (Chief Executive Officer)

Employment Policies and Practices: Recruitment

There practices are converging towards the American HRM model for most of the Japanese subsidiaries. Selections of new recruits now are based on performance rather than interpersonal skills. Moreover most subsidiaries would not mind to hire the best candidate from outside the organization for a pre-defined position if no suitable employees were found within the organization. Short-term employment relations are also on the rise with some organizations preferring to engage employees on fixed term basis. Below are the comments given by the Local Human Resource Director and Local Human Resource Manager;

Company A: 'Our recruitment style is very much based on ad-hoc. We have no preference to recruit new graduates from the top universities in Malaysia. But if you are a graduate from Japan, we would hire you. The top positions within the company are normally occupied by our internal staff and we will never hire someone outside from the organization. However beyond the management level, we are trying to recruit the best employees for a pre-defined position from outside the organization. We certainly would prefer experienced employees than the inexperienced one. This is because many good employees left due to recession and now we need experienced employees to train those without any experience. EQ is certainly important for us, but we would prefer IQ for the white-collar employees.' (Local Human Resource Director)

Company B: 'We are certainly more stringent in our recruitment during this recession. Previously we do not open up vacancy for outsiders unless it's a new position, but as a result of the recession, many good employees have left us. We have no choice but to recruit experienced employees for the particular job. We make sure that our blue-collar employees passed the product knowledge test, have some basic knowledge on reading electric circuits, schematic diagram and basic mechanical circuits prior to hiring. In terms of promotion, if our internal staff is not experience enough, we will not hesitate to recruit employees from outside the organization. In terms of our selection preferences, although good behavior such as cooperativeness, attitude and willingness to try are important to us, we would prefer to recruit

employees with high IQ. Why? At this point of recession, we need to hire employees who are aggressive, energetic and intelligent so that they are able to guide the organization out of this recession and by helping to push the older employees to be more competitive.' (Local Human Resource Director)

Company D: 'We are recently recruiting employees based on contract rather than on a permanent basis. Although interpersonal and EQ are important in our recruitment, IQ nevertheless is given more emphasis. We certainly would like the best people to occupy the job. We have implemented several new tests for our blue-collar employees prior to hiring. For example, we now have 'drawing test'. (Local Human Resource Manager)

Remuneration systems: Welfare system

In terms of the welfare system, there is no indication that the welfare is orienting towards the American HRM model. Although the recession has implication on the welfare systems to some extent, the features however still resemble closely to the traditional Japanese HRM style. Below are statements made by the Factory Manager, Local Human Resource Director and Local Human Resource Manager;

Company A: 'In term of bonus payouts, it is contractual of 1 month regardless of the employee's position in the Company. Moreover our organizations do not discriminate in terms of welfare benefits. All employees regardless of the category (except the top management level) receive the same benefits and there had been no change even during the recession. For example, full attendance (RM70), meal allowances (RM15), transport (RM70), and housing allowances (RM60). Benefits for the top management level however have been decreased to save cost.' (Factory Manager)

Company B: 'The bonus payment is 1 month like previously. Allowances and benefits are equal for both the blue and white collar employees. However if you are at the managerial level, there are added allowances such as car, cell phone and entertainment allowances. However due to recession, we have limited the allowances. However, there are no changes to the benefits for the non-managerial employees.' (Local Human Resource Director)

Company E: 'Bonus payment used to be twice a year, but due to recession, we pay 30-40 percent lower for each of the bonus payout. There are no changes to the benefits among the blue and white collar employees. However we have eliminated some activities which do not add value such as annual dinner and local trip. Entertainment, medical and car allowances have also been reduced at the managerial and expatriate level. Unlike before, they also need to pre-apply for the allowances.' (Local Human Resource Manager)

Remuneration systems: Promotion System

However on the promotion system, there seems to be a declination in the seniority principle. There are evidences that employees are being promoted regardless of the length of service.

This however is exceptional and not widespread. In general, most of the Japanese subsidiaries still value the seniority principles. Likewise behavior and internal promotion are still heavily stressed while on the whole, MBO still serve no purpose apart from formality. Below are the comments given by the Local Human Resource Manager/Factory Manager/First-line Supervisor;

Company A: 'Promotion for the blue and white collar employees is still based on the seniority principle even after the recession. Behavior is still important as part of the appraisal system and we have no plan to abolish them. Although promotions are based on seniority, we do promote exceptional employees. However, that will not lead to higher pay. We only give out additional administrative allowances.' The director further gave an example of an employee has been promoted rapidly and is currently heading one of their sister subsidiary in Johor, Malaysia. Whether there are changes in terms of promotion preference, he concluded that the internal promotion is still very much preferred although he thinks this will be unlikely in the near future. On the appraisal system, the manager stressed that the MBO is just for formality as it is part of the organization's requirement. 'Grades will be revealed for the white-collar employees but not the blue-collar employees, but at the end of the day they serve no purpose.' (Local Human Resource Director)

Company B: 'There is no indication that promotion is moving towards the merit system. As for now it is still very much based on seniority. Again behavior is also important for both the blue and white collars. The policy remains that the vacancy for any higher posts are meant only for their internal staff. However, external employees will be taken into consideration if there is a vacancy for a new post. MBO is also conducted but not revealed.' (First-line supervisor)

Company C: 'The promotion system for our employees is moving towards the merit system. However, the weightage for behavioral function is given more emphasis than performance function. Promotion is still very much internal based while external recruitment is only for new post. MBO is a close concept. We conduct the MBO as it is part of the organization procedures but we do not reveal the results.' (Local Human Resource Manager)

Company D: 'Our promotion system for the blue-collar employees is based on seniority and also 'attendance'. Seniority assessment however is only limited to 60 percent for the white-collar employees. Merit performance however is important for the top management level. We have tried to push for the implementation of MBO style across the board but was not approved by our headquarter in Japan'. (Local Human Resource Manager)

Career development practices: training and development

The training and development style of the Japanese subsidiaries are still very much geared towards generalist approach. Much effort has also been given to mould the culture of the particular employee with the organization's culture by training and focusing on work group more than the particular individual. Hence we doubt that there is any convergence towards the American HRM model. Below are the statements given by the Factory Manager, First-line Supervisor and Factory Manager;

Company A: 'Shaping the employees' character towards our organization's culture is very important regardless of the employee's ranking. As such, we normally have a long employee orientation to introduce our employees to our work and organization's culture such as the practices of 5S and so on. Moreover we have Japanese classes organized by FMM. Our training is overall oriented towards maintenance and not related to job improvement in view of the high accident rate. Training for the white-collar is however selective and is in accordance with their job scope and not based on their preference or interest.' (Factory Manager)

Company B: 'Our training is more focus towards work group than on individual. Our training needs are planned by the production side rather than the HR department. Our training days for the blue-collar employees are between 5 and 6 days while the white-collar employees are between 3 and 4 days. The additional days are for safety and health classes. We like to give a wide range of training to our employees rather than a specialized one.' (First-line supervisor)

Company D: 'Our training funds come from the HRD funds. On most of the occasion, the HR department will propose the training as the HRD funds are parked under their belt but at the end of the day, the production side will decide whether to give the green light or not. Teambuilding training is very much stressed as our culture emphasized a lot on good teamwork.' (Factory Manager)

The Future of Japanese HRM

On the perception and view of the future of Japanese HRM practices in Malaysia, will it be replaced by a full American HRM model one day? Is the Japanese HRM outdated? What are some of the Japanese HRM elements they wish to retain and change? Here are some of the opinions of the Chief Executive Officer, Managing Director, Local Human Resource Director and Local Human Resource Manager;

Company A: 'The Japanese HRM practices are not outdated but there are certainly things that can be further improved. Take for example the inclusion of MBO and merit payment in the appraisal system. We would certainly like this to be adopted. The American HRM has never been any source of inspiration in our company. Perhaps the Japanese way should be the best approach in view of the failure of the American model during this recession in the United States.' (Managing Director)

'The senior management team in our Japan headquarter are mainly between 60-70 years old. Although most Japanese expatriates and CEOs at Malaysia are oversea trained and have a flair ideas of American HRM, they are unlikely to adopt them. This is in view of their character which is to respect the elderly and in most of the situation; the elderly would certainly not want to change to this new approach.' (Local Human Resource Director)

Company B: 'The Japanese are taking back control of their subsidiaries' as a result of the recession, by replacing the local Managing Director with their expatriates. As such the

management-style within our local subsidiaries resembles much closer to the traditional Japanese HRM. Moreover many Japanese companies are now becoming more conservative as the result of the recession and many key decision needs permission from our headquarter in Japan.' (Managing Director)

'One reasons why Japanese establishes their firm in Malaysia is due to cost saving. By practicing the American HRM, the product cost will increase due to job specialization, merit payments and so on. Moreover the American model emphasis too much of human rights and this may hamper the way we run our business in Asia. Take for example the working hours. We are not saying that we have bad ethics but too much of rights and protections will slow our production and this is impossible for Asian companies like us to survive!.' (Local Human Resource Director)

Company C: 'There will not be changes in terms of whether we will like to adopt to the American HRM as at the end, the decision is very much dependable on the management teams who are Japanese expatriates. They are unlikely to change as most of them are from the technical background, e.g., engineering. So long as the company is making profit, why need to change? Moreover most expatriates' contract is between 3-5 years, thus they have no motivation to change anything drastic in view of their short term duration here. They would of course prefer status quo.' (Managing Director)

'The American HRM practices although are very flexible in a way but at the same times it is very insecure. Like for example the hire and fire style. This is not motivating for our employees. Thus we have no plan to introduce the full practices here at Malaysia. Many staff in our organization are not also ready for the American way as we have many staff who has been attached here for a long time and have been very customized to how the Japanese HRM practices are being practiced.' (Local Human Resource Manager)

Company D: 'The Japanese HRM is certainly outdated and not good for the growth of the organization. Promotion and remuneration for example must be based on merit. However the Japanese HRM are here to stay and it would be impossible for us to move on to a total American HRM model. Our Japanese expatriates are very conservative and only want to implement whatever they know best. Moreover implementing the American HRM can be very costly. So long as the American model can be cost effective we would certainly be happy to adopt them, but their HRM system does not work in this way.' (Local Human Resource Manager)

Company E: 'The Japanese HRM is outdated and no longer relevant. Our Japanese headquarters are already moving away from the traditional Japanese HRM. However the American HRM are still not being adopted here in Malaysia.' One possible explanation he stressed was due to the resistance by some of the employees. 'Many employees have already been with the company for a long time, thus they are very comfortable with the Japanese HRM as they felt that it is more stable and secure.' (Managing Director)

CONCLUSION

The paper has attempted to evaluate whether there is a convergence towards the American HRM practices. Research findings from the above interviews in Malaysia present a very mixed picture. The staffing practices previously resembled a hybridization model. In view of the recession, the practice now resembles closely to the American HRM model. In terms of the welfare system, there is no indication that the practices are orienting towards the American HRM model. However on the promotion system, there seems to be a declination in the seniority principles. There are evidences that employees are being promoted regardless of the length of service. The case however is exceptional and not widespread. In general, most of the Japanese subsidiaries still value the seniority principles. Likewise behavior and internal promotion are still heavily stressed on, while MBO still serve no purpose apart from formality. Thus, we opine that there are indications of movements towards the American HRM model although they are not particularly strong. By and large, training and development practices are also not orienting towards the American HRM model. The training and development style of the Japanese subsidiaries is still very much geared towards generalist style except for a few fields. Lastly, evidences suggest that the recruitment practices are already orienting towards the American HRM model. Selections of new recruits now are based on performance rather than interpersonal skills. Moreover most subsidiaries would not mind to hire the best candidate from outside the organization for a predefine position if no suitable employees were found within the organization.

Thus in relation to the emergence of 'dominance effect' on the Japanese subsidiaries, findings conclude that the effect will not take place on practices which would lead to higher production cost. This will probably be true for all emerging markets context. American HRM interestingly was never viewed by any of the subsidiaries as their source of inspiration. In fact the local management does not have much confidence in the particular model as it's regarded as costly, burdensome and does not provide much flexibility. Ironically, local managers are against the idea of adopting to a total American HRM model. Whether the Japanese HRM model will be outdated? It is too early to predict as the conclusion is mixed. Japanese HRM is still regarded as practical and cost effective by the Japanese subsidiaries. However, majority of the respondents agreed that they should do away with seniority principles, more merit payments, benefits and promotions and realistic MBO. Thus, will there be an end to the Japanese HRM model in the coming years? Insights and perspectives from the top managements suggested otherwise. Strong conclusive points were given. Japanese HRM practices will go through major reforms especially in staffing and recruitment practices while the other practices are likely to remain as hybrid or resemble the Japanese HRM practices due to economic considerations and organization strategies.

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STOCHASTIC FUNCTION APPROXIMATION BASED NEURAL NETWORK

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ABSTRACT

Using discrete event simulation is a popular choice in complex system evaluation. However, to identify the right set of system parameters, which give the best system performance, is a time consuming process due to stochastic uncertainty behavior of system simulation. This research demonstrates an alternative method to the discrete event simulation as a system model where system performance can be evaluated within a short period of time in comparison to discrete event simulation. However, typical approximation function based neural network need to be re-trained when setting environment has changed. This research intends to address both weakness in the time of simulations and a rigid structure of system learning of neural network.

The objectives of this research is to develop and study the scalable artificial neural network system for approximating performance function in case study of the buffer optimizing of pull-control system of multiple workstations, the network system separated 3 types of single workstation by training data from simulation are initial workstation, intermediate workstation and final workstation, approximation by interconnecting 3 types of network systems and to study factors that affect the performance function approximation efficiency, performance measure are the average number to meet demand (sale), the average number to not meet demand (lost sale), the average of work-in-process and the average cycle time.

From the study, the neural network system can use to approximate performance measures of this case study system. The approximation function based neural network does not only determine the mean of the stochastic system performance but also its variation (the length of the mean confidence interval). Therefore, we can use this approximation function based neural network to find the size of appropriate buffer much more quick than does the method by simulation optimization.

Keywords: Artificial Neural Network, Function Approximation, Stochastic Search, Variation analysis.

INTRODUCTION

A simulation model is regarded as popular and established method to solve a problem. Moreover, it is also used to study a complicated stochastic system because it is adjustable into many types for policy test before real practice. However, it has to take a long time to apply the simulation model to find an optimal solution. If the most proper solution is needed, the more time is required to repeat process to retain the best parameter value of the system because of abundant possible incidents which are nearly impossible in practical way as shown in table 1. Several applied methods for optimization algorithm such as Branch and Bound Algorithm may cause difficulties and limitations. Another interesting technique is artificial neural network. It is able to be used for data analysis gained from the simulation model not depending on distribution types. Besides, it can be utilized to analyze incomplete data but average value is not enough to be representative of the stochastic system. Therefore, variation value is another necessary parameter for consideration as well.

Table 1: Time to find the number of buffer

Number of workstation	Number of feasibility	simulation: days (20 sec/event)*	Neural Network: Days (2 sec/event)*
3	24,000	6	1
4	640,000	148	15
5	16,000,000	3,704	370
10	102,400,000,000,000	23,703,703,704	2,370,370,370
15	491,520,000,000,000, 000,000	113,777,777,777,778, 000	11,377,777,777,777,800
20	2,097,152,000,000,000 , 000,000,000,000	485,451,851,851,852, 000,000,000	48,545,185,185,185,200, 000,000

***** Estimate time from computer spec Intel®Core™Quad 2.66 GHz, ram 3 GB

THEORY AND RELATED WORKS

The artificial neural network system is a processing technique that developed by basic principles of creature' neural network. The artificial neural network work likewise a brain to collect knowledge through learning process and keep it as weight which is adjustable when accepting new things. General aspects of the developed network are different weight of connection link between each node and signal. The weight value is regarded as the knowledge gathered for specific problem resolution. There is a function within the node to determine output signal or called transfer function. The characteristics of node in the artificial neural network are presented in Figure 1.

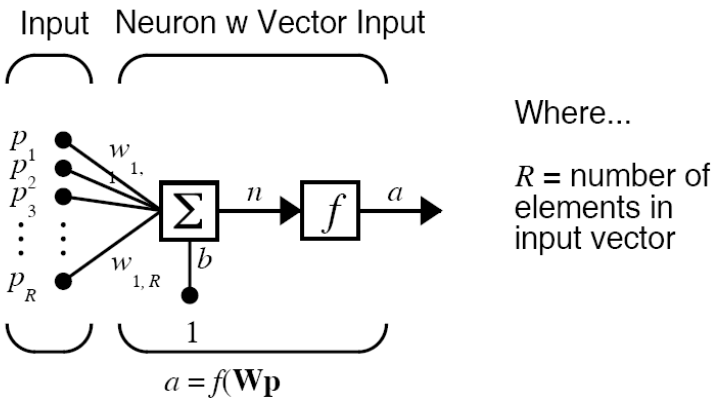

Figure 1: Neural Network Model

The production pull control system has special characteristic such as the data production will flow reversely to the flow of material. The latter production process will take necessary material when needed by using Kanban card to bring the material of the earlier production process. After that, such process has duty to only produce sufficient amount to reach equal number of taken materials or following the Kanban card. (Monden, 1994)[5]. It can be said that the latter process will control the production rate of the earlier process as show in Figure 2.

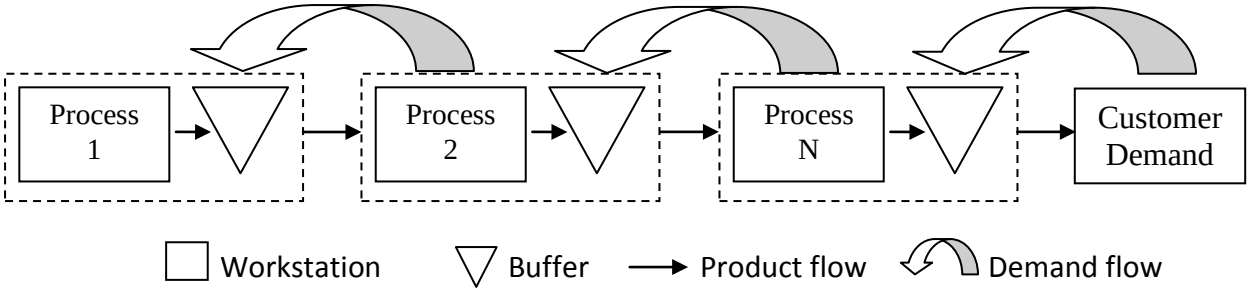

Figure 2: Pattern of pull control system

Albino (1995)[1] studied to increase efficiency of throughput time evaluation and work-in-process for Kanban system analysis and design to suit real production line. He applied the creation of the queuing system's model by using Markov process to evaluate behavior of the pull production process. A significant characteristic of this evaluation is simple allocation of production line used for the queuing system like M/M/1/L. The result found that the behavior of the pull production process and other greater production lines could be well evaluated by this method.

Neural Network is extensively used to forecasting. Chambers (2000)[2] investigated the buffer size of the queuing system by studying possibility of single workstation building to forecast the result of the queuing system. The single workstation is connected following the queuing system of two products and used the back-propagation artificial neural network to teach the network. According to the situation simulation, the connected workstations in the queuing system can

predict the performance value of the system which is an approximate with the result of the situation simulation.

In 2006 Fulya (2006)[3] applied the back-propagation artificial neural network to identify the buffer quantity in asynchronous assembly systems by using the data from situation simulation to compare with a prediction method, regression metamodels. The analysis showed that the back-propagation artificial neural network can be use as the suitable model to identify the buffer quantity with low sensitiveness. Furthermore Piromya (2006)[6] used the back-propagation artificial neural network to assess the performance of the pull production process consisting of 3 and 4 workstations. The data apply for teaching neural network is collect from the situation simulation to examine the result of different data of entire possible situation of the system. It found that the evaluation of the artificial neural network is a very good level. Besides, when there are more data in the network, the efficiency of system's performance evaluation also increased too.

Manusak (2007)[4] developed and studied the scaleable artificial neural network system for performance function approximation in case study of the buffer optimizing of pull control system of multiple workstation ,the network system separate 3 types of single workstation by training Data from simulation are initial workstation network , intermediate workstation network and final workstation network , approximation by interconnecting 3 types of network systems. From the study, the scaleable artificial neural network system can use to approximate performance measure of this case study and from this studying factors that affect the performance efficiency, increasing the factor of number of workstation in the system make the efficient of approximation decrease. For sample size used training network increased make the efficient of approximation increase.

METHODS

Because of stochastic system is determine mean and variation, therefore approximation function not should consider only mean but it should approximate variation too. This research use concept of Scaleable Aritifitial Neural Network System: SANN for create pull system model, in order to be training data for neural network. The situation simulation of the pull production control system is divided into three types of single workstation including initial workstation, intermediate workstation and final workstation. The initial workstation is the first workstation and the intermediate workstation is the second workstation to the workstation n-1, n is number of total workstations in the system and the end single workstation is the last workstation or 'n' workstation.

After that, three models of the situation simulation are created. The data collect from the situation simulation of each workstation is brought for the network teaching to produce the three types of the networks. The pull production control system with several workstations can be built by SANNS to link each workstation and evaluate 8 performance values including average response time of sale, variation response time of sale, average response time of lost sale, variation response time of sale, average of cycle time (CT), variation of cycle time, average

of work-in-process (WIP) and variation of work-in-process.

The artificial neural network is a hidden layer with 20 nodes using two levels of data that teach in the network at 30% and 50% of all data. Probability of processing time is normal distribution with standard deviation at 5% of the processing time (P) of each workstation only. The processing time value is between 0.6-1.0 separated by 0.1 time unit in each interval. The highest buffer size (B) is 5 while the lowest buffer size is 2. The demand rate (D) are dispersed as exponential distribution with average of one processing time at 0.8, 0.9, 1, 1.1, 1.2 of time unit and normal distribution with average of one processing time at 0.8, 0.9, 1, 1.1, 1.2 of time unit, standard deviation at 5% of processing time.

Mean case, the method of network connection start from checking the pull production control system if there is any workstation with highest processing time or not. If such workstation is found, it will be defined as a bottleneck workstation. Then the average of demand rate of any earlier workstation of the bottleneck workstation will be equal to reverse value of time to submit into each type of networks. The outcome is the average of production interval regarded as the input rate for the next workstation. This process will thoroughly run in whole workstations as demonstrated in Figure 3 - 4.

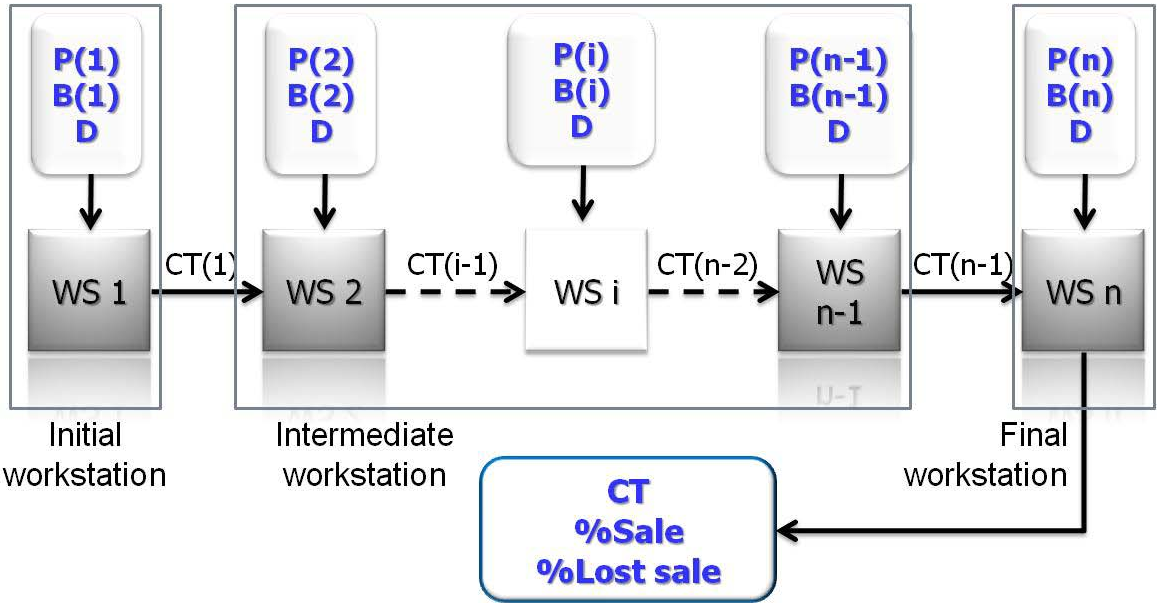

Figure 3: Connector of workstation for find mean of cycle time, %sale and % lost sale

Because of work in process of previous workstation have effect to work in process of next workstation therefore work in process is necessary become to input for find suitable weight.

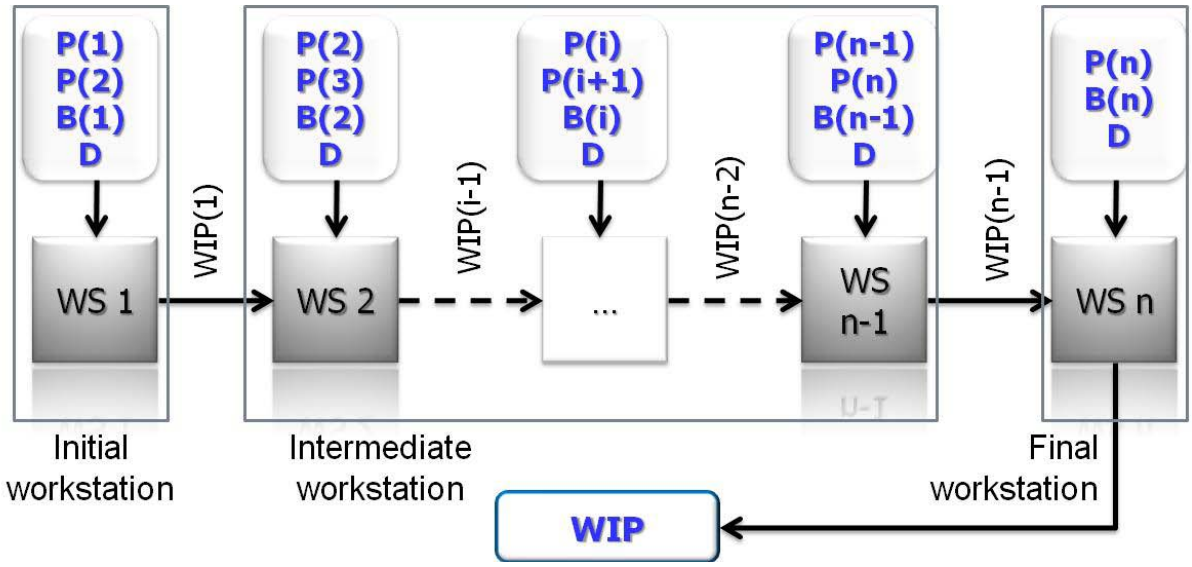

Figure 4: Connector of workstation for find mean of work in process

Variation case, add standard deviation of processing time as input of interconnect of network as demonstrated in Figure 5 – 6. In case of demand is normal distribution, add standard deviation of demand as input of interconnect of network as demonstrated in Figure 7 - 8.

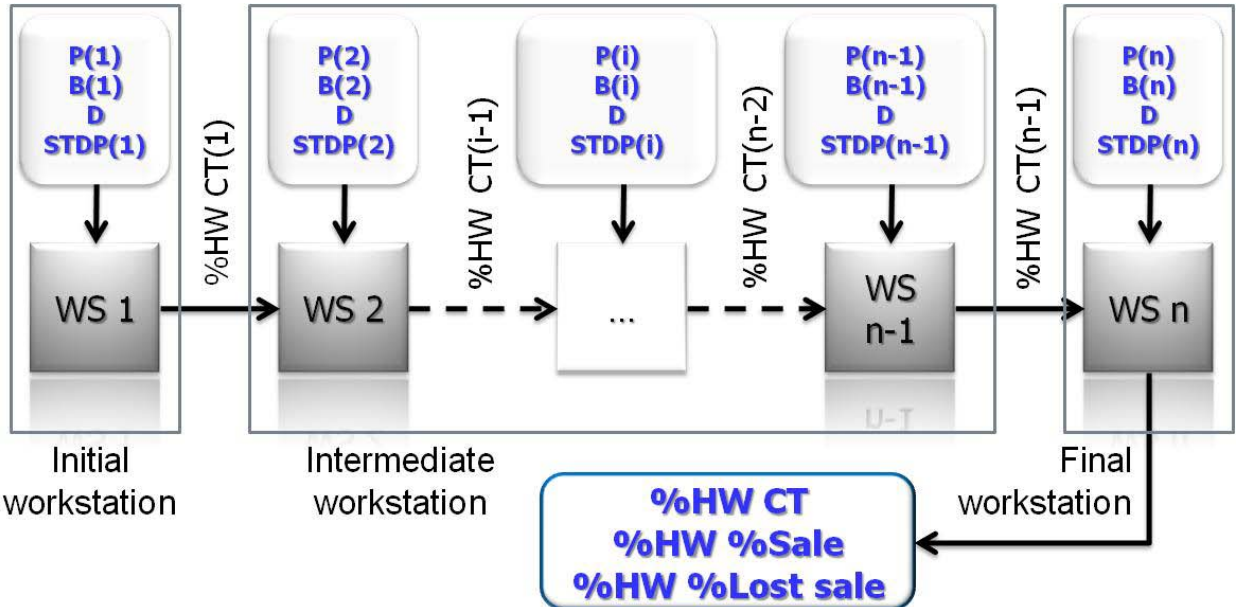

Figure 5: Connector of workstation for find variation of cycle time, %sale and % lost sale (Demand: Exponential distribution)

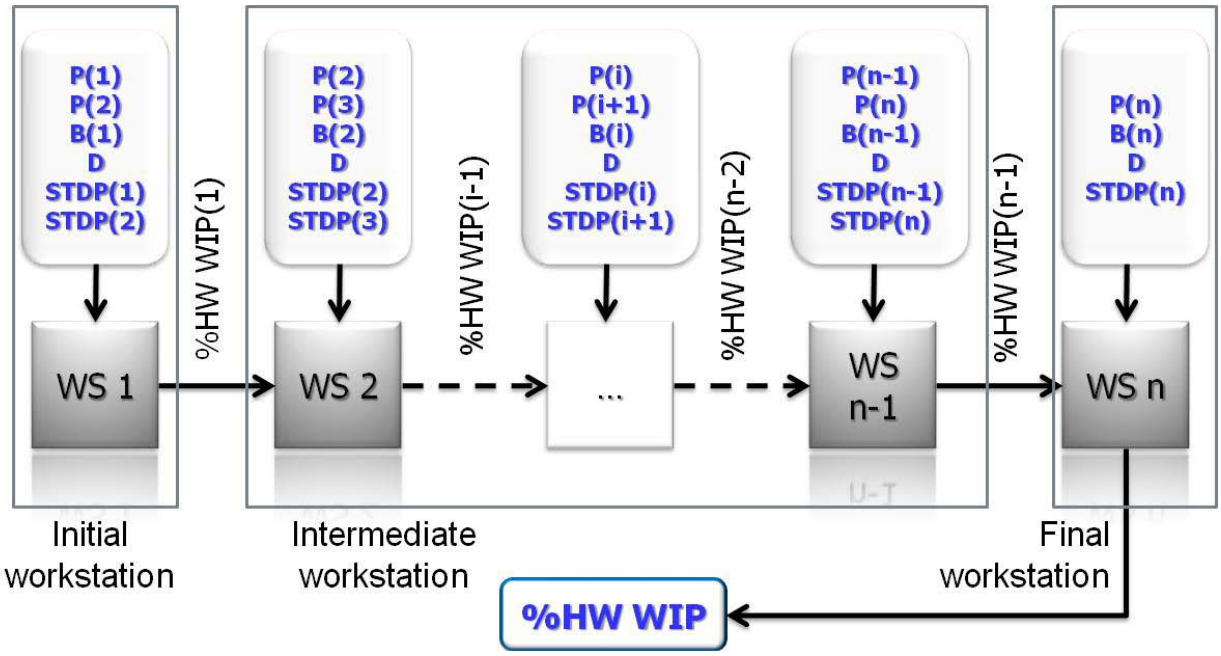

Figure 6: Connector of workstation for find variation of work in process
(Demand: Exponential distribution)

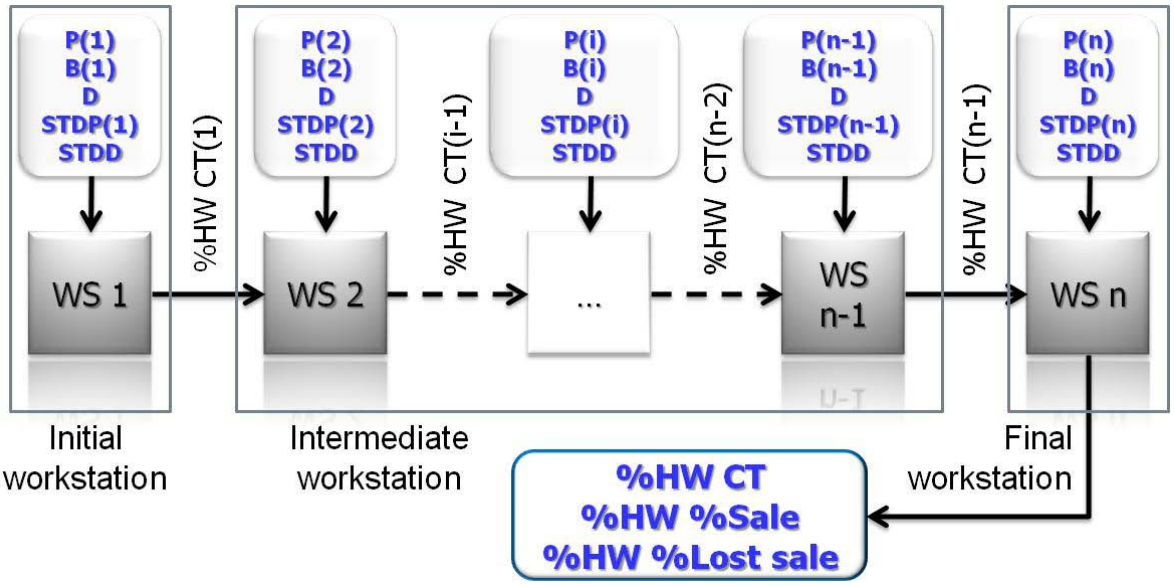

Figure 7: Connector of workstation for find variation of cycle time, %sale and % lost sale
(Demand: Normal distribution)

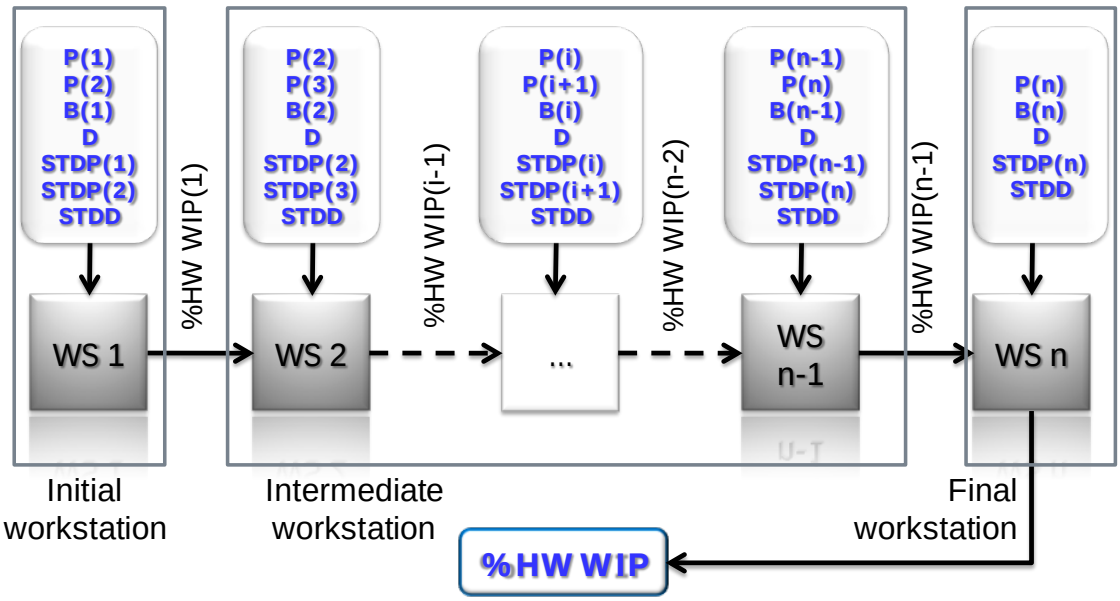

Figure 8: Connector of workstation for find variation of work in process (Demand: Normal distribution)

Training network use data from pull system simulation at 3 workstation. Then use weight acquired from network to estimate value of pull system at 4, 5, 10, 15 and 20 workstation. Collect 5,000 simulation examples per 1 system for compare with value that estimate from SANN. Indicator of mean is R-Square and indicator of variation is ratio of number error data per all data (%Miss).

After that, test capability by change standard deviation of processing time from 0.05 to 0.01. Collect 1,000 data for estimate value. Use weight from network that used training data 50% of all. Consider efficiency of mean with R-Square and variation with ratio of number error data per all data (%Miss).

RESULTS AND DISCUSSION

R-square is used to measure the efficiency of the result as illustrated in Table 2 - 3.

Table 2: R-square value of mean (Demand: Exponential distribution)

R-Square	%Train	Number of workstation					
		3	4	5	10	15	20
Cycle Time	30%	0.99	0.99	0.99	0.90	0.76	0.70
	50%	0.99	0.99	0.99	0.98	0.98	0.98
Work in process	30%	0.97	0.93	0.91	0.66	0.54	0.58
	50%	0.97	0.91	0.90	0.78	0.69	0.70
R-Square	%Train	Number of workstation					
		3	4	5	10	15	20
%Sale	30%	0.99	0.88	0.71	0.40	0.38	0.37
	50%	0.99	0.99	0.97	0.96	0.95	0.93
%Lost sale	30%	0.99	0.99	0.98	0.84	0.77	0.72
	50%	0.99	0.99	0.98	0.97	0.96	0.94

Table 3: R-square value of mean (Demand: Normal distribution)

R-Square	%Train	Number of workstation					
		3	4	5	10	15	20
Cycle Time	30%	1.00	0.82	0.71	0.52	0.55	0.49
	50%	0.99	0.99	0.97	0.84	0.91	0.91
Work in process	30%	0.98	0.96	0.94	0.68	0.64	0.65
	50%	0.97	0.96	0.95	0.83	0.50	0.78
%Sale	30%	1.00	0.99	0.97	0.90	0.78	0.79
	50%	0.99	0.99	0.97	0.87	0.69	0.72
%Lost sale	30%	1.00	0.99	0.97	0.91	0.77	0.79

50%	0.99	0.99	0.97	0.94	0.74	0.76

Table 2 shows result that SANN estimate mean of system. Data are trained with 50% of all data have efficient more than data are trained with 30% of all data. Besides increase of work station will reduce efficient of estimate mean.

However estimate variation cannot perform with R-Square. From analyst variation data are found that rang of half-width are small gap. So separate rang of half-width to 0%, 1%, 3%, 5%, 7%, 9%, 10%, 15%, 20%, 30%, 40%, 50% and 60% and then get this value to train network for find suitable weight at 3 workstation. Next use this weight to approximate variation at 4, 5, 10, 15 and 20 workstation. Consider efficiency of variation with ratio of number error data per all data (%Miss) as shown at table 4 - 5

Table 4: %Miss value of variation (Demand: Exponential distribution)

%Miss	Number of workstation					
	3	4	5	10	15	20
Cycle time	0.00	0.00	0.00	0.00	0.00	0.00
Work in process	3.63	4.56	4.36	11.28	16.46	18.28
%Sale	0.00	0.00	0.00	0.00	0.00	0.00
%Lost sale	2.17	2.14	1.1	2.34	2.76	2.82

As shown in Table 4 above, estimate %Miss of Cycle time and %Sale do not have error while %Lost sale and Work in process have tend to increase when number of workstation increase. However %Miss are not over 2% and 20% respectively.

Table 5: %Miss value of variation (Demand: Normal distribution)

%Miss	Number of workstation					
	3	4	5	10	15	20
Cycle time	0.00	0.00	0.06	0.00	0.00	0.00
Work in process	1.00	4.44	4.36	0.00	0.18	0.16
%Sale	0.04	0.10	0.20	0.00	0.00	0.00
%Lost sale	1.67	1.30	2.26	3.54	4.88	9.64

As shown in Table 5 above, although number of workstation increase to 20 workstation but %Miss of Cycle time and %Sale are not over 0.5% while %Miss of Work in process are not unstable. However %Miss of Work in process are less than 5%. For %Lost sale, %Miss will increase when number of workstation will increase, but not over 10%.

For test capability, the result of estimate performance of pull system is shown that SANN can estimate mean and variation at standard deviation of demand is 0.01. But efficiency of estimate will reduce when number of workstation increase which shows in table 6 – 9.

Table 6: R-square value of mean (Demand: Exponential distribution)

R-Square	Number of workstation				
	4	5	10	15	20
Cycle Time	0.98	0.97	0.94	0.94	0.94
Work in process	0.93	0.90	0.78	0.69	0.69
%Sale	0.99	0.98	0.97	0.93	0.95
%Lost sale	0.99	0.98	0.94	0.88	0.90

Table 7: R-square value of mean (Demand: Normal distribution)

R-Square	Number of workstation				
	4	5	10	15	20
Cycle Time	0.97	0.97	0.96	0.89	0.93
Work in process	0.52	0.50	0.48	0.47	0.49
%Sale	0.98	0.98	0.97	0.73	0.88
%Lost sale	0.98	0.98	0.96	0.71	0.86

Table 8: %Miss value of variation (Demand: Exponential distribution)

%Miss	Number of workstation				
	4	5	10	15	20
Cycle Time	0	0	0	0	0
Work in process	84.6	85	85.3	88.7	88.6
%Sale	0	0	0	0	0
%Lost sale	92.4	92	91.4	93.4	92.2

Table 9: %Miss value of variation (Demand: Normal distribution)

%Miss	Number of workstation				
	4	5	10	15	20
Cycle Time	81.6	75	45.3	37	77
Work in process	51.4	44.3	52.8	46.4	38.8
%Sale	76.7	66	63.6	59.9	68.6
%Lost sale	99.3	98.5	94.5	85.8	73.3

CONCLUSION

The results of this research show that SANN effectively predicts (approximates) the mean and variation of the four performance measures of the pull-control production system. The recommended train data size is fifty percent of the set of solutions for individual workstation in developing SANN for the Initial workstation, the intermediate and the final workstation. From the results, direct approximation of the confident interval of performance measures is not possible. However, when using SANN to predict the range of variation in all performance measures, the results indicate the effective prediction. The predictability of variation in cycle time and the number of sales are about 99%. The predictability of variation in work-in-process is about 80% due to the impact from the increase of the number of workstations. The predictability of variation in the number of lost sales is about 90% due to the impact from the small and non continuous value of measures. In conclusion, SANN has shown a great promised in accessing the stochastic measures in large production system.

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E2 – Financial perspectives

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Yung-Ming Shiu

E2.2 **The return on equity (ROE) for food sector companies listed on the Warsaw stock exchange**
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E2.3 **Determinants of the financial results in the terms of the world crisis in small and medium sized enterprises in Poland - Analytical approach, part I**
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E2.4 **Determinants of the financial results in the terms of the world crisis in small and medium sized enterprises in Poland - Analytical approach, part II**
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BANK VALUE AT RISK DISCLOSURES AND RISK PREDICTABILITY: THE EFFECT OF DERIVATIVE USE

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ABSTRACT

Banks disclose value at risk (VaR) data that is, in principle, instrumental in predicting the subsequent variability of trading income. Using a sample of 18 United States commercial bank holding companies from 1997 to 2006, we find that VaR is a predictive risk measure. Nevertheless, we find that derivative use reduces the predictability of VaR-based measures of volatility. Thus, investors and analysts are cautioned when using VaR disclosures of banks with large derivative positions.

Keywords: value at risk disclosures, predictability, derivatives, banks

INTRODUCTION

The increase in the number, range, and scope of mandatory disclosures by bank holding companies has been notable; in particular, the publication of value at risk (VaR) estimates by banks has received considerable attention. This was mandated by Financial Reporting Release No. 48 published in 1997 that requires public traded firms to disclose their market risk exposure using a tabular presentation, a sensitivity analysis, or value-at-risk (VaR) (Linsmeier and Pearson 1997). Since then, VaR disclosures have been used by analysts to gauge the market risk of banks. However, several papers have questioned the suitability of VaR as a risk measure. Berkowitz and O'Brien (2002) indicate that banks' VaR models are not superior to a simple volatility measure. Dowd and Blake (2006) further argue that VaR is seriously flawed as a measure of risk. On the other hand, Jorion (2002) and Liu, Ryan, and Tan (2004) find evidence that banks' trading value-at-risk disclosures are informative in predicting the variability of future trading revenues. They also find that derivative use by banks increases the variability of unexpected trading revenues.

Banks, acting both as derivative dealer and end-user, participate in the derivative markets. Over the past decade, banks have been increasing their use of derivatives. Banks' trading revenues have also gradually become more and more important for their profitability.[1]

[1] The 1996 Amendment divides a bank's assets into two categories: the trading book and the banking book. The trading book consists of financial instruments that are traded by the bank and is typically marked-to-market daily, while the banking took mainly consists of loans and is not marked-to-market (Hull 2007, p. 176). Trading-related revenues include direct trading revenues, fees, and interest revenues on trading assets net of the costs to fund trading positions. Trading revenues consist of realized and unrealized gains and losses from trading activities, changes in fair value associated with financial instruments held by the bank for which the SFAS 159 fair value option was elected, and loans held-for-sale within the wholesale lines of business.

Banks' use of derivatives leads to greater variability of future trading revenues. The use of derivatives by banks is sophisticated. As a derivative dealer, banks provide quotes to other market participants, while, as end-user, they use derivative contracts to manage portfolios, or to hedge risk. Empirical evidence on the relation between banks' derivative use and risk is inconclusive. Venkatachalam (1996) and Yang, Song, Yi, and Yoon (2006) find that bank holding companies use derivative contracts to reduce risk. Sinkey and Carter (2000) also note that banks with a higher likelihood of financial distress are more likely to use derivatives to hedge. Thus, the relation between derivative use and risk is an empirical question.

VaR disclosures seem not to properly account for derivative use. In part, this is due to the fact that VaR models have their strengths and weaknesses and work best with particular types of portfolios (Jorion 2000; Linsmeier and Pearson 2000). When optionality in portfolios is significant, the predictability of VaR measures will be adversely affected if the appropriate VaR models are not used. Beder (1995) points out that the increasing complexity and optionality of derivatives makes the scenario selection for VaR calculations even harder. VaR is difficult to apply when portfolios include significant non-linear derivatives such as options and option-like instruments (El-Jahel, Perraudin, and Sellin 1999). For instance, the delta-normal approach entails mapping instruments to delta-equivalent positions and mapping derivatives, especially options, can be more complicated than other assets (Linsmeier and Pearson 2000). The delta-equivalent method inadequately measures the risk of non-linear instruments with asymmetric payoffs because it does not take account of their gamma (convexity) (Jorion 2000; Hull 2007). However, it works well for portfolios with little option content, especially when the holding period is short (Linsmeier and Pearson 2000).

The historical simulation method is onerous for complex portfolio structures (Jorion 2000). The Monte Carlo simulation involves model risk because it requires the stochasticity of underlying market risk factors and pricing models for options. Given these modeling issues, the predictability of VaR is reduced when banks use more derivatives.

Banks' disclosures are intended to reveal their market risk profile. Jorion (2002) was the first to examine the predictability of banks' VaR disclosures. Using a sample of eight banks for the period 1994 to 2000, he finds that VaR disclosures are informative in forecasting the subsequent variability of their trading revues. Using a larger sample of 17 banks from 1997 through 2002, Liu, Ryan, and Tan (2004) also find that VaR disclosures have predictive power for trading revenues variability.

In this paper, we reexamine the question using a larger and extended sample of 18 commercial banking holding companies from 1997 to 2006. As with earlier studies, we find that banks' trading VaRs have predictive power in accounting for the variability of trading revenues, but find that derivative use significantly reduces predictability. To investigate the moderating role of derivative use, we include a variable that interacts the volatility measure inferred from VaR disclosures with the derivative use variable. To our knowledge, the current study is the first to examine the moderating effects of derivative use on the relation between forecasted trading revenues volatility—inferred from VaR disclosures—and unexpected trading revenues.

The remainder of the paper proceeds as follows. Section 2 introduces the sample, data, and research design. In Section 3, we present the empirical results from which we offer some conclusions and their implications in Section 4.

DATA AND METHODOLOGY

To examine the moderating effects of derivative use on the predictability of the VaR numbers, we collect data on U.S. commercial bank holding companies from their 10-Q and 10-K filings from the EDGAR database.[2] Larger banks generally have more technical sophistication with which to develop VaR systems and thus better capability of using VaRs to predict unexpected trading revenues (Liu, Ryan, and Tan 2004).[3] Moreover, these banks generally engage in derivative markets. We therefore collect the data for the largest 100 banks in terms of total assets. Banks without trading revenues, VaR and derivative use disclosures in their 10-Q and 10-K reports are excluded. The final sample includes 18 commercial bank holding companies and 396 firm-quarter observations. Table 1 provides the sample banks' names, total assets, SIC and CIK codes, and the time they first disclosed VaRs in their quarterly and annual filings. Table 2 shows the descriptive statistics for the sample banks.

[2] The keywords used in finding value-at-risk are "VAR", "Value at Risk", "Value-at-Risk", and "trading VaR". We also collect banks' approach to calculating their VaR, confidence level, and holding period.

[3] The initial sample has 987 commercial bank holding companies in this database as of the end of 2006.

Table 1. Description for the 18 U.S. Commercial Bank Holding Companies

Bank	Total assets as of end of 2006 (in millions of $)	SIC	CIK	First VaR disclosure	
				10-K	10-Q
CITIGROUP INC.	1,884,318	6021	0000831001	1997	1998, Q2
BANK OF AMERICA CORPORATION	1,463,685	6021	0000070858	1998	1998, Q3
JPMORGAN CHASE & CO.	1,351,520	6021	0000019617	1994	1995, Q1
WACHOVIA CORPORATION	707,121	6021	0000036995	1997	1998, Q1
WELLS FARGO & COMPANY	527,715	6021	0000072971	2002	2004, Q1
SUNTRUST BANKS, INC.	478,159	6021	0000750556	2002	2003, Q1
REGIONS FINANCIAL CORPORATION	430,398	6021	0001281761	2004	2004, Q3
NATIONAL CITY CORPORATION	261,217	6021	0000069970	1997	NA
STATE STREET CORPORATION	219,232	6022	0000093751	1997	1998, Q1
BANK OF NEW YORK COMPANY	103,455	6022	0000009626	1998	1998, Q1
PNC FINANCIAL SERVICES GROUP	101,854	6021	0000713676	1997	1998, Q1
KEYCORP	92,337	6021	0000091576	1997	1998, Q1
NORTHERN TRUST CORPORATION	60,712	6022	0000073124	1997	NA
UNIONBANCAL CORPORATION	52,620	6021	0001011659	1997	2003, Q1
POPULAR	47,404	6022	0000763901	1999	NA
MELLON FINANCIAL CORPORATION	41,478	6021	0000064782	1996	1996, Q1
BOK FINANCIAL CORPORATION	18,060	6021	0000875357	1998	1998, Q1
UMB FINANCIAL CORPORATION	8,918	6021	0000101382	2003	2004, Q1

Table 2. Descriptive Statistics of Sample Banks (unit: in millions of $)

	Mean	Median	Maximum	Medium	SD
Trading revenue	470	80	8,986	-49	114
Unexpected trading revenue	102	14	3,105	0.04	262
Standardized VaR for 1-day holding period and under the 99% confidence level	65.51	19.08	419	0.05	94.50
Notional amount of derivative contracts	4,011,613	140,778	49,041,398	570	8,426,061
Total assets	309,297	91,501	1,746,248	6,842	394,244

We first scale up daily VaRs collected from banks' 10-Q and 10-K filings to quarterly VaRs using the square root of time rule (Smithson 1999; Jorion 2002; Liu, Ryan, and Tan 2004). According to this rule, we multiply daily VaRs by the square root of 63 to obtain quarterly VaRs based on the assumption that a quarter has 63 working days. We then infer the volatility in quarterly trading revenues from the quarterly VaR divided by α, the standard normal variable. For one-tailed 99%, 97.5%, and 95% confidence levels, the values of α are 2.33, 1.96, and 1.645, respectively. In our sample, most banks present their VaR under the confidence level of 99%. If banks report the VaR under different confidence levels, however, we follow Linsmeier and Pearson (2000) to normalize the VaR.[4]

We measure the unexpected quarterly trading revenues as the difference between the actual quarterly trading revenues and the expected quarterly trading revenues. Like Jorion (2002) and Liu, Ryan, and Tan (2004), the expected quarterly trading revenues are proxied by their moving average over the previous four quarters.

Following Jorion (2002) and Liu, Ryan, and Tan (2004), we examine the predictability of VaR disclosures by estimating the following equation:

$$\text{Unexpected trading revenues}_t = f(\text{VaR-based volatility, Derivative use, VaR-based volatility}\times\text{Derivative use}) + \varepsilon_t \quad (1)$$

where the unexpected trading revenues are proxied by the difference between the actual quarterly trading revenues and the expected quarterly trading revenues; VaR-based volatility is the standard deviation inferred from the VaR disclosures; derivative use is the notional amount of derivatives used by banks, deflated by firm size; VaR-based volatility×Derivative use is the interaction between VaR-based volatility and derivative use.

EMPRICAL RESULTS

Table 3 shows the pooled ordinary least squares regression results for the unexpected trading revenues. The adjusted R-squared across models ranges from 0.31 to 0.37, and their *F*-tests are all significant at the 0.01 level. As expected, VaR-based volatility has statistically significantly positive effects on unexpected trading revenues, suggesting that banks' VaR disclosures have predictive power in forecasting the next quarter's variability of unexpected trading revenues with/without controlling for derivative use. This finding is consistent with Jorion (2002) and Liu, Ryan, and Tan (2004). We also find that the coefficients of derivative use are positive and highly significant. This suggests that banks' derivative use increases the risk of next quarter's trading revenues.

[4] For instance, a bank discloses its daily VaR under the 95% confidence level. The equivalent quarterly VaR under the 99% confidence level is its daily VaR under the 95% confidence level times the product of the square root of 63 and 2.33/1.645.

Table 3. Pooled Ordinary Least Squares Regression Results

	Model 1	Model 2	Model 3
Constant	2.23973	12.17726	0.93998
	(0.171)	(0.949)	(0.070)
VaR-based volatility	1.58355***	0.66880**	0.82719***
	(13.433)	(3.226)	(3.862)
Derivative use		0.01264***	0.02202***
		(5.284)	(5.176)
VaR-based volatility × Derivative use			–0.00004 ***
			(–2.656)
Adjusted *R*-squared	0.31237	0.35635	0.36612
F-value	180.43***	110.35***	77.05***

Notes: ***, **, and * indicate statistical significance at the 1 %, 5%, and 10% levels, respectively.

Finally, we find that the coefficients for the interaction term, VaR-based volatility×Derivative use, is significantly negatively related to unexpected trading revenues, indicating that derivative use adversely affects the predictive power of VaR disclosures.[5] This is possibly because banks' portfolios may include large quantities of options or option-like instruments with asymmetric payoffs. The asymmetric payoff of these instruments reduces the ability of VaR to correctly capture the risk.

CONCLUSION

Prior research has suggested that VaR disclosures reveal the market risk profile of firms. Jorion (2002) and Liu, Ryan, and Tan (2004) finds that banks' VaR numbers significantly predict the next quarter's risk. Due to the complexity of derivative instruments, it is to be expected that the predictability of VaR disclosures should be reduced for banks with large derivative positions in their portfolios.

In this paper, we provide evidence that this has been the case. Using a sample of 18 U.S. commercial bank holding companies reporting trading VaR during the period 1997 to 2006, we find that VaR predicts the subsequent variability of trading revenues. Furthermore, we find that the predictability will be reduced for banks with significant derivative positions.

Our study has a significance for those interested in using risk disclosures made by financial institutions, such as regulatory authorities, analysts, and stakeholders. They are cautioned about the predictability of VaR numbers disclosed by banks heavily engaged in the derivative markets.

[5] As a robustness check, we use an alternative proxy for derivative use, namely the notional amount of derivatives used by banks, and examine the sensitivity of our results. We find that using the alternative proxy does not qualitatively affect the results on other variables.

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THE RETURN ON EQUITY (ROE) FOR FOOD SECTOR COMPANIES LISTED ON THE WARSAW STOCK EXCHANGE

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ABSTRACT

The key systematic issue tested throughout this paper is finding the reason for the relative low representation of the food sector on the stock exchange. Research on the performance of food sector companies within 1998–2008 led authors to the conclusion that one of the potential reasons of such under representation might be low level of ROE relative to the return from available investment opportunities made at the market free risk rate during the matching period.

Polish investors enjoy a large scope of investment options, some relatively safe and capital market risk free, including a number of Treasury Bills and Treasury Bonds.

Key thesis in this paper show substantial discrepancy between the level of return (ROE) on Polish listed food sector companies and the level of return acceptable for investors. For the purpose of the research the authors used several available ways to calculate ROE and compared in this paper to the market risk free rates for the period.

Results clearly confirm that ROE of food sector companies remains on lower levels than the market risk free rates, sometimes even remaining on negative territories.

Keywords: Return on Equity ROE, stock exchange, food sector, market risk free,

INTRODUCTION

The problem of the financial result worked out basing on assets used by the company is present in the practice of corporate finances since the 30's of the XX century, when the pioneer works were conducted in the financial division of the chemical giant Du Pont. The general practice of comparing appropriate elements from companies' financial statements and on these basis calculating appropriate measurements of the companies' performance thus has taken the name of Du Pont system. While describing the issue, authors use sometimes different taxonomy: „Du Pont system" (Ross, Westerfield, Jaffe, 1990, p.42 – 44), (Bodie, Kane, Marcus, 2009, p. 636 – 641), (Brealey, Myers, Marcus, 2001, p. 142 – 146), „Du Pont model" (Brigham, Daves, 2007, p. 259 – 270), „Du Pont equation" (Brigham, Ehrhardt, 2008, p. 132 – 141), while "Du Pont pyramid" is generally used term in Polish language literature.

Within the Du Pont system there are three ratios related to defining return: ROS - Return On Sales, ROA - Return On Assets, and ROE - Return On Equity. The most important for the company's owners is the third ratio which shows how efficiently equity (what in reality is the owners own capital invested in the company) has been used by the company. There are several approaches to which level of the result of the company's business shall be used for the most relevant calculation of the return shall be measured (i.e. what to use as a numerator). It is sure that it should be one of the forms of earnings or profit but the concepts vary starting from the level of net profit to the level of EBIT. In the case of ROE the majority agrees that the numerator should consist of the net profit what in general practice is equal with net profit payable to the owners. However there is a view (Garrison, Noreen, Brewer, 2008, p. 724 – 727) that the numerator should be clearly calculated as net profit corrected by the payment of preferred dividends. This is largely unimportant for the concept of ROE and secondly the voice is an isolated one.

As far as denominator is concerned it is crucial to use a correct figure for equity. The first concept is that it should be the level of equity as stated for the last day of the accounting period. This view was largely present at the initial stages of the development of the concept of ROE (Bień, 2008, p. 99 - 103), (Micherda, red., 2005, p. 63 - 66), (Pastusiak, 2009, p. 99 - 101), (Sierpińska, Jachna, 1996, p. 103 - 107), (Siudek, 2004, p. 185 - 187), (Wędzki, 2003, p. 20 - 23), (Bodie, Merton, 2003, p. 121 - 130), (Brigham, Houston, 2005, p. 119 - 122), (Adair, 2006, p. 46 - 47), (Bodie, Kane, Marcus, 2009, p. 636 - 641), (Brigham, Daves, 2007, p. 259 - 270), (Brigham, Ehrhardt, 2008, p. 132 - 141), (Damodaran, 1996, p. 79 - 86).

Alternatively, it is acceptable to argue that the applicable correct figure for the equity shall be calculated as the simple average of the two consecutive accounting periods, the current and the previous one. This point of view becomes more and more generally recognised since it is acknowledged that the average for the year (the beginning and the end of the accounting period figures) describes the condition of the company more precisely that the fixed figure of the year end (Brealey, Myers, 1999, p. 1083 - 1087), (Bodie, Merton, Cleeton, 2009, p. 83 - 88), (Brealey, Myers, 1991, p. 680 - 682), (Brealey, Myers, 2003, p. 828 - 831), (Brealey, Myers, Marcus, 2001, p. 142 - 146), (Garrison, Noreen, Brewer, 2008, p. 724 - 727), (Harrington, Wilson, 1989, p. 8 - 16), (Ross, Westerfield, Jaffe, 1990, p. 42 - 44).

USAGE OF ROE

In short and simplified summary, the ROE ratio shows the company's ability to generate profits through the period using available means, i.e. the equity. In practice there may be some difficulties in using ROE as a comparison tool to judge the performance of the company – mainly because of the weakness of the net profit parameter which is the accountancy figure versus the real money worked out by the company as shown in the cash flow. Thus net profit is rather more a paper figure than real money in the company's disposal. Because of different law systems and various numerous tax exemptions plus different manners to count depreciation and amortization it is difficult to use ROE ratio as a simple comparison between the companies. It is similarly difficult to use ROE to compare companies from different sectors which have different capital needs.

ROE in % in various sectors in 2007:

Cigarette Industry	35,0	
Iron/Steel making	26.7	
Soft Drinks	19,2	
Banks	17,1	
Data storage	16,5	
Farm products		16,5
Software for business	12,8	
Telecommunication	12,3	
Food	11,8	
Airlines	8,5	

Source: Bodie, Kane, Marcus, 2009, p. 568, from Yahoo! Finance of 5.11.2007

There are other issues that influence usage of ROE (Brigham, Houston, 2005, p. 135) related to business risk, scale of activity and project implementing. Because of its construction, ROE ignores the risk factor. It is possible that a very risky project, that in one accounting period was very successful, in the next period is much worse. In this respect, judging through the past, it would have been better to choose the project with inferior ROE but with a significantly higher risk that would enable generating profit in the long run.

The ROE ratio does not take into account the scale of the project. There are various cases where the high level of ROE is possible to achieve only when investing in projects of lower scale (i.e. not using whole available capital). Managers in such circumstances should rather decide to take on the project of lower ROE but allowing the usage of larger amount of capital.

ROE is as well difficult to use when it deals with sections of an enterprise. It may happen that the managers evaluated solely on the basis of the level of ROE ratio, i.e. have a clear goal of a certain ROE level acceptable, after having reached such sufficient level for the positive evaluation of the management, are then reluctant to take risk of new projects for the fear that this would lower the achieved level of return.

Important feature of ROE is that using the financial statements it is possible to calculate its level from the past (Bodie, Kane, Marcus, 2009, p. 637), but for the recommendations and assessment of the future financial events, it is advised to employ forecasts, not the historical data.

Another significant remark towards ROE is the fact that it is calculated for the nominal values. The calculation for the real figures requires refining the ratio from the effect of inflation. It is particularly important from the point of view of an investor who anticipates the growth of the wealth.

ROE IN FOOD COMPANIES LISTED ON THE WARSAW STOCK EXCHANGE

The aim of this research is to calculate the ROE ratio in the food sector companies listed on the Warsaw Stock Exchange during the period of 1998 – 2008 and formulating using different methods of calculation and indications of its changes. In this respect authors take into consideration two basic methods of calculating ROE

1. ROE end =
Net profit / Equity at the end of the accounting period
2. ROE avg =
Net profit / The average of the equity from the beginning and end of the accounting period

It happens that changes of the equity do not occur during the accounting period or sometimes are relatively small, however, from the point of view of dynamic character of equity and the fact that actual figures are counted in small percentage points it is better to calculate on the basis on the average equity.

The food sector companies listed on the Warsaw Stock Exchange may be characterized by three subperiods within the years 1998 – 2008.

1. 1998 – 1999, when ROE was relatively at low level and in several cases it reached negative territories.
2. 2000 – 2003, when ROE was at relatively low level but the negative figures were sporadic.
3. 2004 – 2008, when ROE was at relatively higher level and the average for the sector reached double figures values.

Analysis of all above companies prove that only in the period 2006-2007 all of them displayed ROE at the positive levels. In all remaining years at least one food company demonstrated the negative ROE.
It is symptomatic that among 8 companies listed constantly on the Warsaw Stock Exchange within the research period, as many as 7 recorded at least once the negative ROE. There is only one company “Jutrzenka S.A.”, which ROE has been always at the positive territories, however, twice only at decimal fractions of a percent. It seems that the fact of listing on the stock exchange, the experience of the management of the publicly listed company, advise from the professional consultants and observing investors’ expectations, and in some cases extorting necessary changes in operations result in gradual growth of the ROE ratio. The periods of the negative ROE are never longer than two years and the return on the positive levels is in majority durable and the gradual consolidation is noted.

For all food companies listed on the Warsaw Stock Exchange in years 1998 -2008 the ROE ratio was calculated with the implementation of both possible denominators: the amount of equity at the end of the year and the average equity for the given year. Calculating the average equity is justifiable, because the profit is made throughout the year, so one has to implement the level, that is the most close to the year average equity.

Table 1. Return on Equity ROE for food sector stock listed companies

Jutrzenka	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	diff
ROE end	7,18	2,90	1,85	3,39	0,53	5,73	20,73	10,49	12,52	32,30	0,71	
ROE avg	7,33	2,88	1,84	3,46	0,52	5,24	23,60	11,07	13,37	38,46	1,07	
(ROEend-ROEavg)/ROEavg	*-2,0%*	*0,8%*	*0,5%*	*-2,2%*	*3,3%*	*9,4%*	*-12,2%*	*-5,3%*	*-6,3%*	*-16,0%*	*-33,8%*	*-5,8%*
Mieszko	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	-15,83	10,48	12,64	2,51	12,17	-36,23	0,23	2,04	3,06	4,26	6,34	
ROE avg	-14,67	11,06	13,49	2,40	14,21	-30,68	0,31	2,06	3,11	4,36	7,01	
(ROEend-ROEavg)/ROEavg	*7,9%*	*-5,2%*	*-6,3%*	*4,5%*	*-14,3%*	*18,1%*	*-24,1%*	*-1,0%*	*-1,5%*	*-2,1%*	*-9,6%*	*-3,1%*
Wawel	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	-23,29	-49,96	8,66	9,75	6,94	10,52	27,72	25,38	32,81	14,25	14,62	
ROE avg	-20,71	-40,26	9,05	10,54	7,09	10,96	32,51	29,08	39,25	15,34	15,27	
(ROEend-ROEavg)/ROEavg	*12,4%*	*24,1%*	*-4,3%*	*-7,6%*	*-2,2%*	*-4,1%*	*-14,7%*	*-12,7%*	*-16,4%*	*-7,1%*	*-4,3%*	*-3,3%*
Indykpol	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	1,17	-7,28	8,77	6,67	3,46	11,79	16,39	17,06	8,81	12,69	-16,01	
ROE avg	1,18	-7,03	10,21	6,88	3,52	12,52	17,86	21,14	9,21	13,55	-14,83	
(ROEend-ROEavg)/ROEavg	*-0,6%*	*3,6%*	*-14,1%*	*-3,0%*	*-1,7%*	*-5,9%*	*-8,2%*	*-19,3%*	*-4,4%*	*-6,3%*	*8,0%*	*-4,7%*
Kruszwica	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	-10,96	-73,43	7,88	6,09	7,56	25,34	19,47	13,47	8,68	7,36	23,59	
ROE avg	-13,58	-53,71	9,13	6,32	7,86	29,01	21,57	13,47	12,09	7,35	25,40	
(ROEend-ROEavg)/ROEavg	*-19,3%*	*36,7%*	*-13,6%*	*-3,6%*	*-3,8%*	*-12,7%*	*-9,7%*	*0,0%*	*-28,2%*	*0,1%*	*-7,1%*	*-5,6%*
Żywiec	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	5,10	6,07	1,50	-0,35	7,02	18,46	9,74	26,51	35,26	49,69	54,32	
ROE avg	8,97	6,23	1,60	-0,39	3,84	18,31	10,27	26,41	30,17	46,31	50,82	
(ROEend-ROEavg)/ROEavg	*-43,1%*	*-2,6%*	*-6,8%*	*-10,5%*	*82,9%*	*0,8%*	*-5,1%*	*0,4%*	*16,9%*	*7,3%*	*6,9%*	*4,3%*
Wilbo	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	12,33	5,33	6,79	1,60	-7,15	2,93	-2,13	-16,30	2,26	9,29	5,53	
ROE avg	13,14	5,33	7,03	1,61	-7,11	2,97	-2,11	-15,07	2,28	9,75	5,68	
(ROEend-ROEavg)/ROEavg	*-6,2%*	*0,1%*	*-3,4%*	*-0,8%*	*0,6%*	*-1,5%*	*1,1%*	*8,1%*	*-1,1%*	*-4,6%*	*-2,8%*	*-0,9%*
Pepees	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	9,40	-2,67	9,64	1,78	0,31	4,46	2,80	-0,24	1,56	85,76	-1,84	
ROE avg	9,73	-2,64	10,15	1,79	0,31	4,57	3,27	-0,24	1,67	71,73	-1,85	
(ROEend-ROEavg)/ROEavg	*-3,4%*	*1,3%*	*-5,0%*	*-0,9%*	*-0,2%*	*-2,2%*	*-14,4%*	*0,4%*	*-6,8%*	*19,6%*	*-0,5%*	*-1,1%*
Food sector average	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	
ROE end	-1,86	-13,57	7,22	3,93	3,86	5,37	11,87	9,80	13,12	26,95	10,91	
ROE avg	-1,08	-9,77	7,81	4,08	3,78	6,61	13,41	10,99	13,89	25,86	11,07	

Table 1: Return on Equity (ROE) calculated on the basis of end of the period figure and on the basis of the average for the accounting period.
Source: own calculations

The results showing the difference between two formulas are presented in the table in the position:
difference between ROEend and ROEavg = (ROEend – ROEavg)/ROEavg x 100%.

The average of these values in the consecutive 11 years is shown in the last column. For 7 among 8 researched companies this deviation is in negative territories between -5,0 and -0,9 % what indicates the systematic growth of the equity in these companies.

The significant remark is that the figures obtained with the calculations using the average amount of equity are usually higher than these obtained with the calculations using the period end figures. Such a phenomenon is to be explained by the fact that the equity in companies has a general growth tendency what is in line with the real sense of the company's existence whose aim is the maximisation of the profit from the owners capital. The part of this profit after taking off the dividend is retained in the company and in the consequence makes the equity grow.

From the point of view of the investor a question arises, how to evaluate the economic gist of the investment in the food sector companies listed on the exchange. For the financial investor the return of such an investment is measured as the total of the paid dividend and the capital gains measured as the difference between the selling price and the purchase price reduced by the transaction costs. Such a view includes in itself two main factors influencing the market price of shares: the company's financial results raising or lowering its value and the influence of general market forces not linked with the financial situation of the particular company – and these two independent factors are always interacting in the same time. If so to exclude the influence of the market forces as general, the basic factor to measure the economic meaning of the investment should remain the net profit. In the context of the capital investment it is shown in the ROE ratio.

In this case the question arises to what level compare the ROE ratio in order to receive the answer for the real meaning of the investment in the given company. It is possible to compare this ratio to the level of inflation to receive the return in the real values rather than in the nominal values. This approach has a substantial limitation because the way of construction of the ratio by taking numerator and denominator from the same moment of time reduces the influence of the inflation.

MARKET RISK FREE INVESTMENTS

An alternative way to calculate the efficiency of the investment is to compare it with the market free risk investments. The scientists from the corporate finance domain do not agree as to the exact definition of the "market free risk investment". In a logic sense, it means the investment at the highest return without any risk. The question of risk is crucial. It possible to assume that the instruments issued by the State Treasury or by a bank of the highest rating are the market risk free instruments. However even at the best banks and even in the case of countries there is a certain risk of insolvency. To create the market risk free investment level it is possible to calculate the average of the deposit interest for all the banks in the given economy. The solution is however not acceptable from the point of view of a real investor because as the place for creating a deposit only one or just a few banks could be used, and they may carry much higher risk than an average for all the banks.

There is a possibility to use the deposit level on the interbank market as this one which is minimal to reach in the given market conditions, so in the case of Poland it may be WIBOR (Warsaw InterBank Offered Rate). The argument to reject this rate is that in the given moment it is a result of the current market forces and its employment at the date of the end of the year bares the risk of tampering with the results.

Another benchmark for the market risk free investment could be one of the National Bank of Poland interest rates. Among these rates the most suitable seems to be the reference interest rate as this one which is the basis to calculate other interest rates and instruments in the national economy. The weakness of this approach lies in the fact that there are no instruments accessible for the financial investors that would use as the basis the reference interest rate.

As the proper benchmark to use as the market risk free investment one can employ only the instruments issued by the State Treasury. From all of them as the market risk free one can point at the Treasury Bills and Treasury Bonds. In respect to the multitude of these papers, the fundamental question arises which of them are the best to implement. In the practice of investment banking as the most suitable one considers 52 weeks Treasury Bills or current Treasury Bonds. Treasury bills are the instruments that bare slightly lower risk but at the same time are less commonly accessible.

From the above reasoning the conclusion comes that the best solution would be to use the return obtained either from 52 week Treasury Bills or from 2 years Treasury Bonds. During the research the list of returns of these bills and bonds was created and the levels were compared. The figures concern the levels from the last trades in the given calendar year.

Table 2. The market risk free investment in Poland

last trades in year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**total**
52 weeks Treasure bills	5,69	5,97	6,37	4,32	4,21	5,74	5,92	
2 years Treasury bonds	5,51	6,14	6,12	4,54	4,62	6,19	5,47	
difference	0,18	-0,17	0,25	-0,22	-0,41	-0,45	0,45	
mean of differences								-0,05

Table 2: The market risk free investment shown as the 52 weeks T-bills and the 2 years T-bonds and the difference between them.
Source: own calculations

In the header of the table the years are put in the meaning of the date of the last trading session for the given year. In the lines of the table there are: return on 52 weeks T-bills, return on 2 years T-bonds, the difference of these instruments in the percentage points, the mean of the differences in the percentage points.

The above conducted calculations show that the long term difference between the return of 52 weeks T-bills and the 2 years T-bonds is negligible, sometimes the first is higher,

sometimes the second, and the mean of the differences for the whole period is very small and amount to only 0,05 of a percentage point.

Table 3. The return on equity ROE versus the market risk free investment

Jutrzenka	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	7,18	2,90	1,85	3,39	0,53	5,73	20,73	10,49	12,52	32,30	0,71
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	7,33	2,88	1,84	3,46	0,52	5,24	23,60	11,07	13,37	38,46	1,07
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Mieszko	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	-15,83	10,48	12,64	2,51	12,17	-36,23	0,23	2,04	3,06	4,26	6,34
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	-14,67	11,06	13,49	2,40	14,21	-30,68	0,31	2,06	3,11	4,36	7,01
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Wawel	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	-23,29	-49,96	8,66	9,75	6,94	10,52	27,72	25,38	32,81	14,25	14,62
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	-20,71	-40,26	9,05	10,54	7,09	10,96	32,51	29,08	39,25	15,34	15,27
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Indykpol	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	1,17	-7,28	8,77	6,67	3,46	11,79	16,39	17,06	8,81	12,69	-16,01
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	1,18	-7,03	10,21	6,88	3,52	12,52	17,86	21,14	9,21	13,55	-14,83
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Kruszwica	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	-10,96	-73,43	7,88	6,09	7,56	25,34	19,47	13,47	8,68	7,36	23,59
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	-13,58	-53,71	9,13	6,32	7,86	29,01	21,57	13,47	12,09	7,35	25,40
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Żywiec	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	5,10	6,07	1,50	-0,35	7,02	18,46	9,74	26,51	35,26	49,69	54,32
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	8,97	6,23	1,60	-0,39	3,84	18,31	10,27	26,41	30,17	46,31	50,82
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Wilbo	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	12,33	5,33	6,79	1,60	-7,15	2,93	-2,13	-16,30	2,26	9,29	5,53
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	13,14	5,33	7,03	1,61	-7,11	2,97	-2,11	-15,07	2,28	9,75	5,68
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Pepees	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	9,40	-2,67	9,64	1,78	0,31	4,46	2,80	-0,24	1,56	85,76	-1,84
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	9,73	-2,64	10,15	1,79	0,31	4,57	3,27	-0,24	1,67	71,73	-1,85
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83
Food sector average	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
ROE end	-1,86	-13,57	7,22	3,93	3,86	5,37	11,87	9,80	13,12	26,95	10,91
Market risk free basis end	12,59	15,83	17,26	10,84	5,69	5,97	6,37	4,32	4,21	5,74	5,92
ROE avg	-1,08	-9,77	7,81	4,08	3,78	6,61	13,41	10,99	13,89	25,86	11,07
Market risk free basis avg	18,33	14,21	16,55	14,05	8,27	5,83	6,17	5,35	4,27	4,98	5,83

Table 3: The return on equity (ROE) versus the market risk free investment.
Source: own calculations.

In line with the above conducted calculations to the further calculations as the market risk free investment it was taken the 52 weeks T-bills as presented by the National Bank of Poland. In practical frame the market risk free maximal investment brings the highest possible rate of return. One can say that it is the highest return for the investor without risk and effort from the side of the investor. As the benchmark it is going to be compared with the ROE ratio of the food sector companies listed on the Warsaw Stock Exchange. For the comparisons two parallel calculations are implemented

1. ROE with denominator as at the end of the year and the return of 52 weeks T-bills as at the end of the year.;
2. ROE with denominator as the yearly average of equity and the return of 52 weeks T-bills shown as the yearly average.

The aim of this research is to show an economic meaning of an investment in the company as such. The crucial counting lies in the proper return on equity and in this context several questions are ignored: a) possibility to achieve capital gain on the stock exchange, b) the dividend, which in practice during this period was very rarely paid on the Warsaw Stock Exchange.

From the point of view of the investor two alternative investments are concerned:

1. In the food sector company listed on the stock exchange with return shown in ROE
2. Market risk free investment assumed in the 52 weeks T-bills.

Some purists say that there should be no use of negative ROE because while there is a net loss at the end of the accounting period one cannot count return because there is no return. In mathematical meaning however the negative ROE shows the loss on the capital invested in the company. ROE is a measure of effectiveness of the equity, but not the real return for the investor – as it is in the case of the 52 weeks T-bills – so it measures how effectively the capital given by the shareholders is employed, but not how much earning it gives. Hence it is treated here as the theoretical measure of the return on investment.

CONCLUSIONS

Characteristic feature is that in the years 1998 – 2001 all food sector companies listed on the WSE has shown the ROE below the market risk free levels. It proves that during these years the investors would have been better of just to buy the alternative market risk free instruments rather than invest in the companies.

There are as well companies that almost in all the years show the ROE below the market risk free investment (Pepees, Wilbo, Mieszko). It leads to the conclusion that the shareholders of these companies would have done better if they have had invested in the 52 weeks T-bills instead.

The positive feature is that during the period 2003 – 2008 majority of researched companies from food sector listed on the WSE have shown that the managers of these companies were able to use properly the equity available.

The food sector is represented on the Warsaw Stock Exchange weaker than it is in the whole Polish economy. This sector is not searched by the financial investors. As the result many companies were withdrawn from the exchange during the listings. The presented research is an attempt to find the answer to the question why the food sector is so little represented on the stock exchange. The indicated low levels of ROE may be one of the crucial reasons. The positive feature is that in recent years the level of ROE is gradually rising.

The practice of the Warsaw Stock Exchange was that the dividend was rarely paid off to the investors and the market was a subject to substantial fluctuations so the capital gain was very unstable.

The same research tool served as well to indicate that at the end of the researched period the food sector companies that survived on the stock exchange began to show the ROE results much higher than alternative ways of the safe market risk free instruments.

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DETERMINANTS OF THE FINANCIAL RESULTS IN THE TERMS OF THE WORLD CRISIS IN SMALL AND MEDIUM-SIZED ENTERPRISES IN POLAND - ANALYTICAL APPROACH, PART 1

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ABSTRACT

As a result of the global crisis, the sector of small and medium-sized enterprises identify and partially will continue to identify a number of dysfunctions in the financial condition leading to growth of financial insolvency and bankruptcy. The changes in the macroeconomic condition have had and still will have a negative impact on the operating results and financial conditions of companies.

In the situation in which the great financial crisis took down almost all of the world markets, either directly or indirectly having an impact on the financial situations of enterprises. An important research problem seems, to develop in such circumstances as the level of profit/ loss in SME in Poland. The study will cover service companies located in the Westpomeranian Region. An sample of 288 companies were selected at random, making it possible to generalize the results of research.

The data was analyzed using: the volatility of the financial results for the entire group of companies as well as ‚for analytical purposes will be transferred between companies into quartiles. Additional calculations were carried out for the 10th and 90th percentile. This analysis will permitted the separation of these groups to determine which parties and under which circumstances caused their rankings. The analysis was carried out in 6 groups (quartiles, and percentiles), which may help identify distinct behavioral strategies in the future depending on the obtained level of net profit or loss.

Studies carried out in the article will serve as the foundation for creating model solutions, and collectively can bring important information about theoretical or/ and practical implications.

Key words: financial results, small and medium-sized enterprises

THE FUNCTIONING OF SMALL AND MEDIUM-SIZED ENTERPRISES IN CRISIS – FROM THE PERSPECTIVE OF THE IMPACT OF GLOBAL CRISIS

Changeability of environment causes that contemporary companies are more often vulnerable to functioning in a crisis. There are many definitions of a crisis in reference books and so far no uniform definition has been worked out. Although, the diversity in the extant crises literature has caused the refinement of a clear definition of crisis to be problematic at best, but it has allowed researchers to identify some common characteristics of all crises.

The term ‘‘crisis’’ is typically used as a catchall concept encompassing a variety of ‘‘un-ness’’ events (Hewitt 1983). Events that are considered to be crises in nature are usually

characterised by high consequence, low probability, ambiguity, and decision making time pressure (Hills, 1998; Pearson and Clair, 1998) It applies to situations that are unwanted, unexpected, unprecedented, and almost unmanageable and that cause widespread disbelief and uncertainty (Hermann, 1963, Carley & Harrald, 1997, Rosenthal, Boin, and Comfort 2001; Stern and Sundelius 2002).

It can be accepted that: A crisis in a company is a process determined by a range of events and situations synchronized in a specific period of time, and as a result leading to the dysfunctions of basic company actions (Porada – Rochoń 2006).

According to the research done by M. Porada – Rochoń[1] at the turn of 2007 and 2008 it is clear that 69% of Polish and as many as 81% American companies have already experienced a crisis at some point. It must be emphasized that the crisis in the enterprise can occur in any phase of the cycle of his existence. The crisis is an integral process in the functioning of a modern company. The crisis is a normal, transitional period to the next stage of development.

We live in an era in which business-related crisis is relatively commonplace. For business managers who are responsible for seeing their business through crises, the questions are no longer whether they will experience crises, but rather when and in what form. Successfully navigating a crisis will depend on the actions a business takes in the time between accepting that crisis can happen and the actual crisis itself.

Typically, the crisis causes the deterioration of the financial health of businesses, starting with reduction in sales and ending with the fall in earnings, which, consequently, often leads to bankruptcy. The financial crisis, that begun in the summer of 2007 was an extraordinarily complex event with multiple causes. Although it concentrated in the United States but quickly metamorphosized into a global financial crisis where financial institutions teeter on the edge of bankruptcy in many countries in addition to the United States. A global economic crisis ensues in which nonfinancial firms around the world appear to spiral downward as well. Companies around the world have had to cope with its effects. The crisis and the rapid change implies the need for an active, forward-looking thinking and effective action. Every company, even in the face of adverse consequences compilation, may retain its competitiveness, undoubtedly.

Especially small and medium enterprises[2] and entrepreneurs play a significant role in all economies and are the key generators of employment and income, and drivers of innovation

[1] The author did carried out research in 2007 and 2008 on financial restructuring processes of 167 Polish and 115 American companies Presented results are some part of the result of research grant of Polish government. no 113.

[2] Definition of micro, small and medium enterprises according EU legislation Micro, small and medium-sized enterprises are defined according to their staff headcount and turnover or annual balance-sheet total (European Commission, 2005): A medium-sized enterprises are defined as enterprises which employ fewer than 250 persons, and whose annual turnover does not exceed 50 million euro or whose annual balance-sheet total does not exceed 43 million euro. Small enterprises are defined as enterprises which employ fewer than 50 persons and whose annual turnover and/or annual balance sheet total does not exceed 10 million euro. Micro enterprises are defined as enterprises which employ fewer than 10 persons and whose annual turnover and/or annual balance sheet total does not exceed 2 million euro.

and growth. During the period since the global financial crisis began, SMEs in many economies have seen demand for their products fall, have experienced difficulty in obtaining working capital, and in many cases have been forced out of business. With customers canceling orders and delaying payment, many SMEs have had problems with liquidity, and have found themselves urgently seeking bank loans. However, banks tend to lack confidence in SMEs' financial health and their ability to achieve sales growth in the future. Banks' cautious lending policy has in many cases amounted to a freeze on the granting of loans to SMEs, and SMEs' funding costs have increased dramatically.[3]

According to OECD Report: The Impact of the Global Crisis on SME and Entrepreneurship Financing and Policy Responses, there is evidence that SMEs in most countries are confronted with a clear downturn in demand for goods and services if not a demand slump in the fourth quarter of 2008. Many expect a further worsening to come. For SMEs there are two related stress factors: a) increased payment delays on receivables which added - together with an increase in inventories- result in an endemic shortage of working capital and a decrease in liquidity and b) an increase in reported defaults, insolvencies and bankruptcies.

Extended payment delays on receivables, especially in times of reduced sales, are leading rapidly to a depletion of working capital in many countries. For example, in Belgium 43 % of surveyed SMEs recently experienced extended delays in their receivables and in the Netherlands 50 % of SMEs have to deal with longer payment terms from their customers. In New Zealand, the share of enterprises waiting over 60 days for payment has risen dramatically from 4.8 % to 29.5 % between February 2007 and 2008. In Denmark, Italy, Ireland, Norway and Spain the surge in corporate insolvencies was higher than 25 %. In Finland, while short-term solvency problems among SMEs normally involve 6-8 % of these firms, in January 2009 more than 17 % of small firms with less than 50 employees declared insolvency problems. In Sweden, according to ALMI (the Swedish state owned Development Bank), bankruptcies increased over 50% in the first two months of 2009 compared to the same period in 2008. Table 1 presents select countries in terms of indications on the magnitude of demand shock.

[3] Principles and Checklist of Financial Crisis Management for APEC SMEs . This document is the output of APEC Symposium on SME Strategies to Manage the Impacts of the Global Financial Crisis held in 2009 in Taipei, and was endorsed by 2009 APEC SME Ministerial Meeting.

Table1: Indications on the magnitude of demand shock.

Country	Assessment of intensity of experienced or expected demand shock
Australia	According to a survey conducted among small enterprises only (firms employing up to 19 employees), more than 1/2 reported either an increase or no change in sales;. In terms of anticipations, almost 2/3 were expecting a recession to occur within the next year. According to another survey covering enterprises with up to 199 employees, business confidence fell during the Q1-2009 to its lowest level, also showing a record low in the sales performance indicator. Only around 31 per cent of enterprises reported facing no problems in their business. Lack of work or sales is the primary concern of SMEs Q1-2009, remaining close to its highest level since May 1998. Medium-sized businesses were more confident than small businesses.
Belgium	According to an "Access to Finance" survey, 60% of respondents report falling sales as the main manifestation of the crisis, followed by a worsening of their financial condition (52%) and extension of their clients' payment delays.
Canada	According to Business Barometer (Dec 2008) : 29% of SME owners say their performance in 2008 was much stronger than in 2007, while 40% say performance is much worse or somewhat worse. Only 17% expect improvement and 44% anticipates worsening performance.
Finland	For a majority of SMEs, orders or pre-orders have been postponed (47%) or cancelled (24%) during the last few months. Demand conditions were worsening further from Q3-2008, when postponed orders affected 34% and cancellations 14% of SMEs.
Germany	According to the National Federation of Independent Businesses, in Q4-2008 poor sales were seen as the single most important problem for 25% of businesses, while financial issues were a top concern for about the same proportion of enterprises.
Greece	The current economic crisis has affected businesses in different ways: for 58% it has been through insufficient working capital, for 55% by way of insufficient sales.
Italy	According to Eurostat, retail trade volume fell by 4.9% in December 2008 compared to December 2007 (new car registrations fell by 17.2%). According to Istat (National Institute of Statistics), exports in 2008 rose by 2% compared to 2007, but fell during the last quarter (5.5% in December 2008 as compared to December 2007. Industrial orders in manufacturing fell by 13.1% in December 2008 compared to the same period of 2007. Business confidence recorded in the ISAE (Institute of Studies and Economic Analysis) surveys has fallen in recent months to all-time lows in all the sectors.

Source: Source: Country Responses to the OECD WPSMEE Questionnaire on the Impact of the Global Crisis on SMEs and Entrepreneurship Financing and the Policy Responses, launched on 14 January 2009 and publicly available information. (in:) The Impact of the Global Crisis on SME and Entrepreneurship Financing and Policy Responses Organisation For Economic Co-Operation And Development OECD 2009.

The financial condition of Polish companies due to the crisis have been quite badly damaged but only in 2008. The strongest impact of the crisis was evident in the financial decline in net financial result. Compare 3Q of 2009 to 3Q of 2007 reported 57% decrease, but compare 3Q of 2009 to 3Q 2008 was evident 40%. According to Polish economists forecast in 2010 net financial result is expected to increase.

The year 2009 showed that Polish companies are able to adjust their activities to current business conditions. The year 2009 was said to bring a crisis which would lead to the loss of mld PLN and thousands of Poles were said to lose their jobs. Yet, the companies in Poland coped with this situation perfectly and financial results support it. However, according to A.T. Kearney, Poland can benefit from a global crisis – in their opinion Polish companies coped well with the first wave of a crisis but they should be prepared for a decrease of orders.

Experience from previous crises suggests that even short-lived shocks can have adverse permanent consequences. Being laid off during a recession can have a scarring effect; evidence from Finland suggest that those laid off during a recession suffer an earnings penalty that only gradually declines over time (Verho 2008). Shocks can also have a lasting adverse effect on firms, as crises may drive otherwise viable firms out of business (Dollar and Hallward-Driemeier 2000; Casacuberta and Gandelman 2009).[4]

However, at the present time, SMEs have been especially hard hit by the global crisis. These firms are more vulnerable now for many reasons: not only has the traditional challenge of accessing finance continued to apply, but new, particularly supply-side, difficulties are currently apparent. It is important to stress that SMEs are generally more vulnerable in times of crisis for many reasons among which are:

- it is more difficult for them to downsize as they are already small;
- they are individually less diversified in their economic activities;
- they have a weaker financial structure (i.e. lower capitalisation);
- they have a lower or no credit rating;
- they are heavily dependent on credit and
- they have fewer financing options.

SMEs in global value chains are even more vulnerable as they often bear the brunt of the difficulties of the large firms. There is evidence that SMEs in most countries are confronted with a clear downturn in demand for goods and services if not a demand slump in the fourth quarter of 2008. Many expect a further worsening to come. For SMEs there are two related stress factors: a) increased payment delays on receivables which added - together with an increase in inventories- result in an endemic shortage of working capital and a decrease in liquidity and b) an increase in reported defaults, insolvencies and bankruptcies. [5]

INTRODUCTION TO EARNINGS MANAGEMENT

Earnings represent the single most important item in the financial reports. Earnings are closely monitored by several parties including financial analysts, executives, and boards of directors etc. The significance of earnings is further emphasized by the fact that the medium and long-term stock returns are overwhelmingly explained by the firm's cumulative earnings. Earnings also have implications for senior executives' employment and compensation benefits.[6] Schipper (1989) defines earnings management as purposeful intervention in the external financial reporting process, with a view to obtaining private gain for stockholders or managers.

Recent studies show, that generally during recession or crisis, companies generate lower financial result compare to economic expansion. Earnings is sensitive to the business cycle.

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[4] P. Paci, A. Revenga, B. Rijkers, Coping with crises. Why and how to protect Employment and Earnings. Policy Research Working Paper 5094, The World Bank Poverty Reduction and Economic Management Network Poverty Reduction Unit October 2009, pp.1-25.

[5] The Impact of the Global Crisis on SME and Entrepreneurship Financing and Policy Responses Organisation For Economic Co-Operation And Development OECD 2009.

[6] Ch. Charoenwong, J. Pornsit, Earnings Management to Exceed Thresholds: Evidence from Singapore and Thailand,, 2008 Electronic copy available at: http://ssrn.com/abstract=1104523.

Individual firms may have different incentives for earnings management. However, the tools that firms use in managing earnings can be systematically associated with the decomposition of total accruals.[7]

In II part of the paper : DETERMIANTS OF THE FINANCIAL RESULTS IN TERMS OF THE WORLD CRISIS IN SMALL AND MEDIUM -SIZED ENTERPRISES IN POLAND – ANALYTICAL APPROACH, PART II there will be extend the theoretical approach to earnings management. The paper will analyze the determinants affecting level of financial results, for small and medium-sized enterprises used in our sample over the years 2006-2009. Particularly interesting seems to establish the factors that shape these financial results (profit or loss) enterprises under the conditions of the recent financial crisis. The study will cover Poland, chosen at random (the sample consists of 288 commercial companies)

PURPOSE AND METHODOLOGY OF RESEARCH

The data was analyzed using: the volatility of the financial results for the entire group of companies as well as ,for analytical purposes will be transferred between companies into quartiles. Additional calculations were carried out for the 10th and 90th percentile. This analysis will permitted the separation of these groups to determine which parties and under which circumstances caused their rankings. The analysis was carried out in 4 groups (percentiles), which may help identify distinct behavioral strategies in the future depending on the obtained level of net profit or loss.

DESCRIPTION OF THE EXAMINED COMMUNITY

Table 1 presents selected variables characterising small and middle enterprises covered by the study. They were divided into equal groups according to their net financial result and were analyzed within these groups. Due to the distribution of variables, the figures presented are median, and not average, values. It was established that companies with higher net financial result are characterised by a larger scale activity expressed as net sales income. Enterprises from 3G and 4G exhibited considerably even several times higher sales levels. Thus, it may be assumed that enterprises from 1G and 2G (as regards sales volumes) were entities smaller than enterprises classified to 3G and 4G. From the point of view of the great financial crisis that took place in the years 2007-2008 it is clearly visible that in 2008 in enterprises from 1G sales diminished and that in enterprises from 3G it was considerably reduced in 2008 r. as compared with 2007 (by nearly 50%). Enterprises from 2G, in which in 2007 sales income was by far higher than in years 2006 and 2008, exhibited significant fluctuations as regards sales volume. The only entities which in 2008 increased their sales (as compared with the preceding year) ware enterprises from 4G.

The observed fluctuations in the sales volume did not directly translate into changes in the total assets value. Enterprises from 1G systematically increased book value of their assets, whereas assets of enterprises from 2G diminished. The situation was similar in the case of enterprises from 3G. In confrontation with the value of fixed assets it must be noticed that this was mainly due to changes in the level of working assets. Conducted analyses

[7] Yoon, S. and G. Miller, Earnings Management of Seasoned Equity Offering Firms in Korea, International Journal of Accounting 37 (2002a), pp. 57–68.

demonstrate that enterprises from 1G systematically increased the value of their fixed assets by way of executing investment projects in spite of a difficult macroeconomic situation. Enterprises from group 2G and 3G increased the value of their fixed assets in 2007 as compared with 2006, but in the following year their value diminished. In 4G the level of fixed assets systematically decreased and entities from this group curbed their investment projects. Slightly different relationships may be observed as regards the level of equity. Taking into consideration that in particular during the financial crisis equity is an indicator (or at least some security) of the enterprise's financial standing, changes in the level of equity observed in 1G, 2G and 4G must be assessed as positive. A significant decrease in the level of equity was observed in entities from 3G, in particular in 2008, which is a disturbing phenomenon (cf. Fig. 1.).

Table 1: General characteristics of the studied enterprises [in Euro].

Position	Years		
	2006	2007	2008
Sales			
1G	135000	161984	102658
2G	335369	1107485	294079
3G	1411726	2292276	1193340
4G	5273208	3899966	6342527
Total assets			
1G	218584	741929	1080324
2G	854266	709737	655598
3G	652986	759835	565774
4G	3238680	1885519	2836797
Fixed assets			
1G	109288	236118	530316
2G	235626	352991	243649
3G	108819	292286	134236
4G	1223082	1207688	1173740
Equity			
1G	19349	78130	153488
2G	133641	122042	128868
3G	307173	405920	295755
4G	1122187	1182729	1953151

Source: own work.

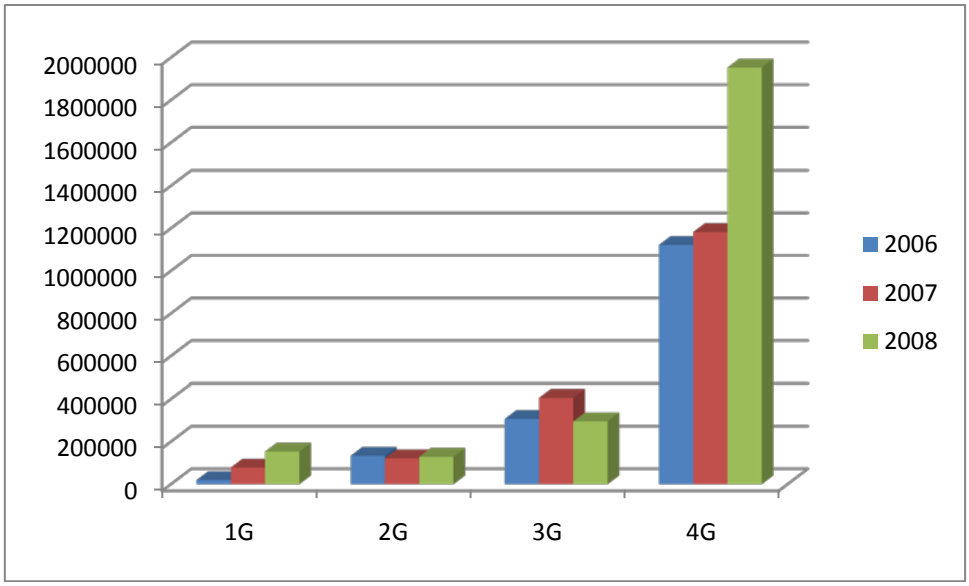

Fig. 1: Equity according to quartiles.
Source: own.

Table 2 presents selected financial variables characterising the enterprises covered by the study. Among the most important parameters illustrating the financial situation of enterprises in the times of financial crisis there are: stock levels, receivables and short-term investments. These variables determine an enterprise's ability to cover its current liabilities. The ability to settle the enterprise's liabilities in a timely manner is the precondition for remaining on the market, in particular in times of unfavourable macroeconomic conditions. Especially interesting are large stock fluctuations in the studied groups of entities. Stock levels were particularly high in 1G in the years 2006-2007, which could be due to accumulation of products that were difficult to liquidate (1G comprises enterprises which on average sustained losses). What is also alarming is the fact that in 2008 the value of stock in enterprises from 2G increased several times and a significant rise in stock levels in enterprises from 4G. In general, it must be noticed that in all groups of enterprises (with the exception of 3G) there could be observed considerable fluctuations in stock levels, which was most probably caused by the financial crisis and which thus must be assessed as a negative development (from the point of view of the entities' financial situation).

It is worth noting that these considerable fluctuations in stock levels were not reflected in varying levels of receivables. They increased significantly in enterprises from 1G and 4G, which can be explained with payment difficulties of their contracting parties. It was established that enterprises classified to 2G and 3G were in a good shape. The level of their receivables went down, which in connection with increased sales must be assessed positively, as it (indirectly) points to an improvement in the financial liquidity of these entities.

A very interesting phenomenon was observed as regards short-term investments (cf. Fig. 2) in 1G and 3G. In these groups short-term investments systematically increased, indicating that the enterprises maintained higher levels of cash and cash equivalents, which was probably due to the operation of the prudence motive (in the Keynesian approach[8]).

[8] Cf. Keynes J.M., 2003. *The General Theory of Employment, Interest and Money*, PWN.

It is also worth noting that enterprises were classified into individual groups according to their net financial result. In the analysed years enterprises from 1G on average sustained losses (which increased in the subsequent years of the crisis). Enterprises from 2G neither sustained losses, nor generated profit. Managers of enterprises from 3G achieved variable financial results exhibiting neither an upward, nor a downward tendency. As regards enterprises from 4G, they systematically increased their financial results. On this basis it was established that the level and direction of changes in the financial result in the studied groups of enterprises was diversified (cf. Fig. 3).

Table 2: Selected financial variables characterising the enterprises covered by the study [in Euro].

Position	Years		
	2006	2007	2008
Inventories			
1G	141556	334410	27751
2G	41488	8340	386417
3G	57796	58789	6762
4G	95367	113871	241562
Receivables			
1G	39752	67853	151189
2G	177451	119059	97270
3G	167731	220668	161993
4G	739381	553771	836877
Short- term investments			
1G	8940	18904	23032
2G	44245	53869	26227
3G	19836	58537	127828
4G	317961	236416	176115
Net financial result			
1G	-26200	-48861	-131584
2G	0	0	0
3G	51733	93896	82268
4G	285537	311303	400209

Source: own work.

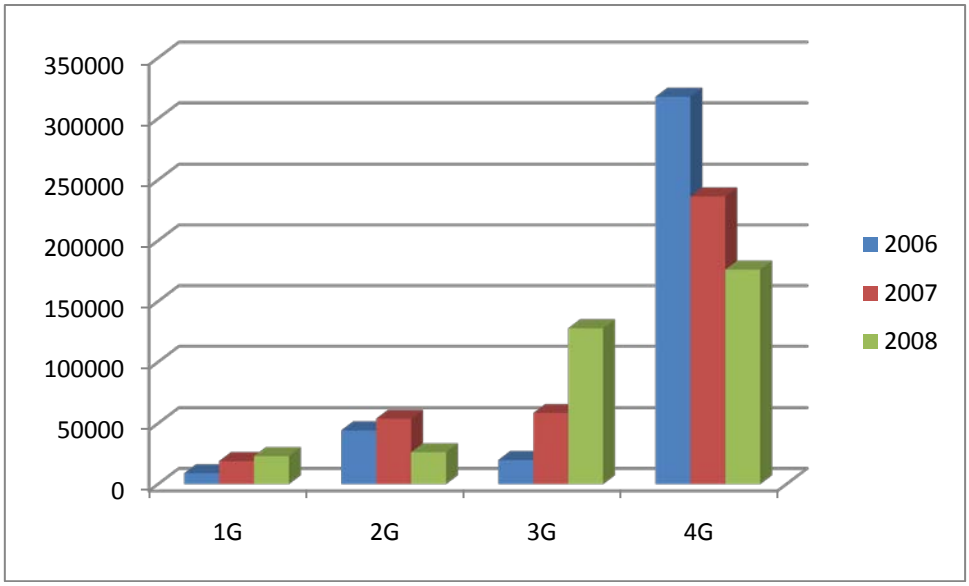

Fig. 2: Short-term investments according to quartiles.
Source: own.

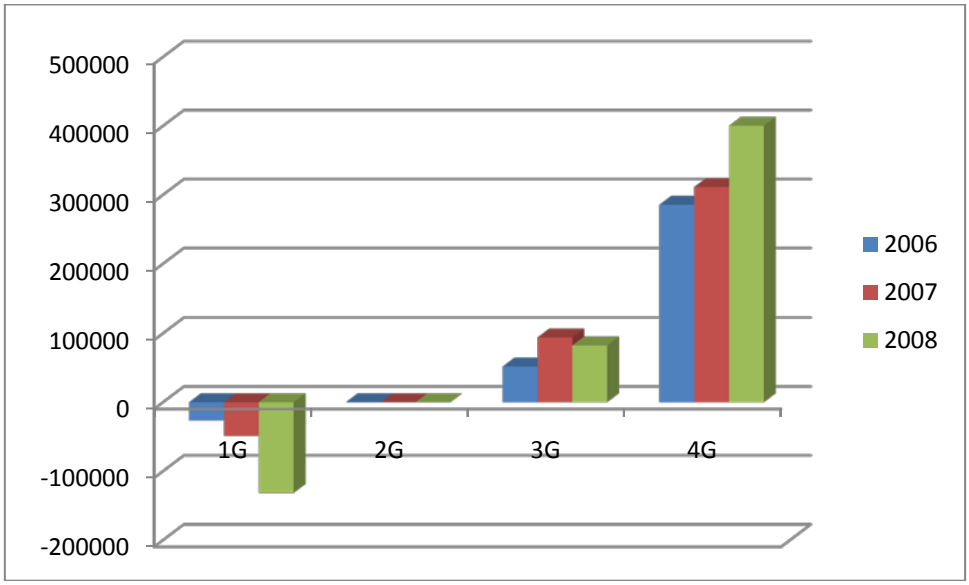

Fig. 3: Net financial result according to quartiles.
Source: own.

Table 3 presents selected financial indicators describing individual groups of enterprises covered by the study. As no enterprise can effectively operate on the market if it does not settle its liabilities upon maturity, the context of the study was taken into due consideration. It was observed that enterprises from 1G exhibited the lowest liquidity indicators, which were below recommended levels. Other groups of enterprises were characterised by current liquidity levels which may be assessed as optimal (enterprises from 2G and 4G) or excessively high (enterprises from 3G, in particular in 2008). Taking into consideration the difficult macroeconomic situation, slightly higher current liquidity indicators may not be assessed as inappropriate, as many enterprises consistently maintained liquidity indicators on a higher level. This observation finds its confirmation in the quick liquidity ratios, which in enterprises from 2G, 3G and 4G were also much above the recommended level. Only immediate liquidity ratios may be considered target values. What is interesting here,

however, is group 3G in 2008, when this ratio amounted to 0.92, i.e. was much above the recommended level. Taking into consideration the macroeconomic situation, it must be stated that enterprises acted rationally in that they preferred to maintain liquidity on levels higher than the ones characteristic for enterprises outside the times of crisis.

From the point of view of efficient management we should also note the return on equity, which in 1G enterprises due to sustained losses was negative, and in 2G enterprises amounted to 0. Enterprises classified to 3G considerably improved their profitability ratios in 2007, but they worsened in 2008 (this was caused by significant fluctuations in the value of equity). However, enterprises from 4G managed to maintain return on equity on a relatively stable level. Similar relationships were observed in the case of return on assets (ROA).

Another parameter that is worth analysing in the times of the great financial crisis is the share of equity in total liabilities. It is not without cause that special attention is paid to the level of self-financing and the capacity to increase the share of equity in liabilities. Share of equity in liabilities in enterprises from 1G was varying and on the downward trend, which was due to the losses incurred. Poor financial results (expressed as net financial result) also precluded enterprises from 2G to significantly increase their level of self-financing. Enterprises from 3G maintained share of equity in total liabilities on a relatively stable level. Enterprises from 4G, which systematically increased the level of self-financing and consequently their financial security, were in best shape.

Table 3: Selected financial indicators characterising the enterprises covered by the study.

Position	Years		
	2006	2007	2008
Lowest liquidity (current ratio)			
1G	0,94	0,74	0,80
2G	1,51	1,60	1,04
3G	2,02	1,98	2,70
4G	1,99	1,81	2,04
Quick liquidity (quick ratio)			
1G	0,67	0,61	0,49
2G	1,04	1,23	0,82
3G	1,82	1,57	2,10
4G	1,53	1,59	1,66
Immediate liquidity (short--term liabilities)			
1G	0,08	0,08	0,03
2G	0,13	0,34	0,07
3G	0,21	0,29	0,92
4G	0,45	0,33	0,21
ROE			
1G	-6,03	0,00	-5,31
2G	0,00	0,00	0,00
3G	15,26	31,18	19,23
4G	36,13	37,49	32,38
ROA [%]			

1G	-9,09	-9,78	-10,81
2G	0,00	0,00	0,00
3G	10,21	11,68	10,06
4G	12,64	16,41	15,15
Share of equity in total liabilities [%]			
1G	20,02	11,27	16,71
2G	30,98	49,76	33,49
3G	57,86	56,18	59,98
4G	51,17	54,94	60,55

Source: own work.

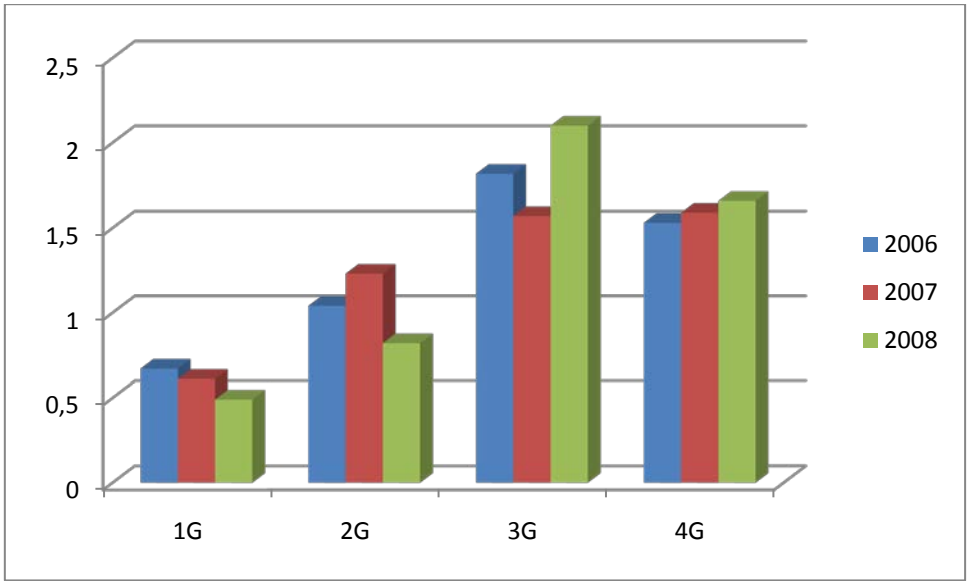

Fig. 4: Quick liquidity according to quartiles.
Source: own.

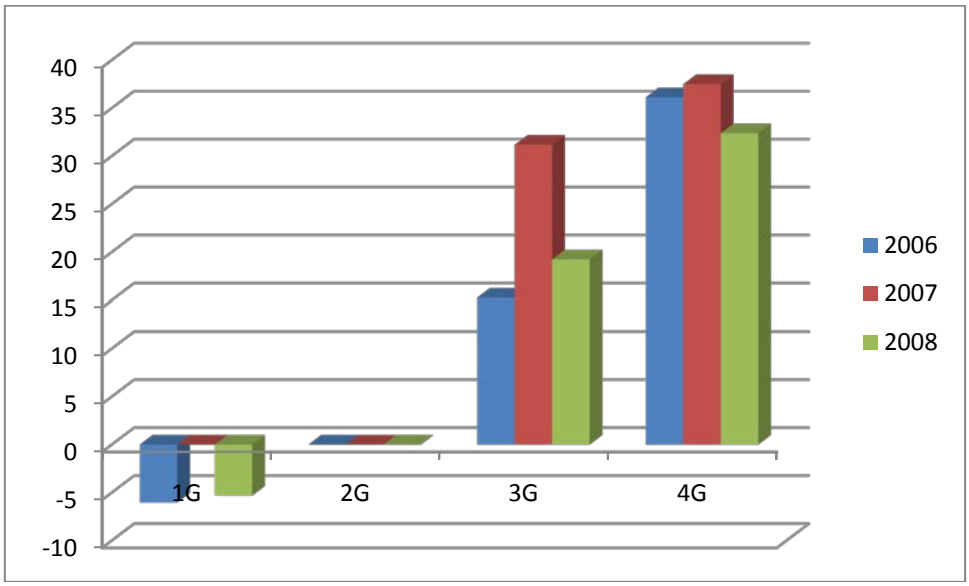

Fig. 5: ROE according to quartiles.
Source: own.

SUMMARY AND CONCLUSIONS

1. It was established that financial indicators fluctuated within the groups of enterprises covered by the study in response to the microeconomic situation, i.e. the great financial crisis.
2. Division of sample enterprises into four groups according to their net financial result allowed to select entities which sustained losses, neither sustained losses nor generated profit, and two groups of entities with higher and highest net financial results. This rendered it possible to establish some regularities typical for periods of crisis.
3. The enterprises covered by the study were characterised by instability as regards sales income, fixed assets and total assets levels. Therefore, it may be concluded that they had problems with a systematic sell of the manufactured goods and execution of investment projects. This phenomena had their roots in the macroeconomic situation.
4. It was established that enterprises strived to maintain financial liquidity, which found its reflection in higher levels of cash and cash equivalents that were maintained. There was visible the prudence motive as regards levels of cash and cash equivalents, which translated into a satisfactory level of all liquidity ratios.
5. Enterprises which achieved best financial results in the times of the great financial crisis systematically increased the level of self-financing and their financial security. They also exhibited an upward tendency as regards profitability, i.e. return on assets and return on equity, which must be assessed as a positive tendency. The conducted analyses demonstrate also that enterprises from 4G were to the least extent affected by the great financial result.

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DETERMIANTS OF THE FINANCIAL RESULTS IN TERMS OF THE WORLD CRISIS IN SMALL AND MEDIUM -SIZED ENTERPRISES IN POLAND – ANALYTICAL APPROACH, PART II

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ABSTRACT

This paper analyzes the determinants affecting level of financial results, for small and medium-sized enterprises used in our sample over the years 2006-2009. Particularly interesting seems to establish the factors that shape these financial results (profit or loss) enterprises under the conditions of the recent financial crisis. The study will cover Poland, chosen at random (the sample consists of 288 commercial companies). The collected data are a balanced panel, so it is possible to eliminate random fluctuations.Results obtained will attempt to verify hypothesis: in terms of financial crisis on the final level of financial results of small and medium-sized enterprises are the variables different from the classic, familiar with the science.

To test the hypothesis, research was be carried using out extensive literature and analysis will be applied to a model: a classical method of the smallest squares and fixed effects model.

Qualities of application of research results – in a situation in which clearly would be able to get the determinants influencing the financial results and economic value added of small and medium-sized enterprises in Poland – during the recent financial crisis, it would give an opportunity for entrepreneurs to pay special attention to these factors and to influence the final shape built up the financial result. In the longer term, it is the financial result is the goal, or provide opportunities to achieve their development goals.

Key words: financial results, small and medium-sized enterprises

INTRODUCTION

The traditional concept of the business, which is striving to establish profit maximization is often criticized as unrealistic, and bypass the many important aspects of economic activity of the company. This theory claims that the unrealistic assumptions not only about the same for the business, but also about her relationship with the environment, lack of regard for the interests of other stakeholders, motifs of human behavior in the company making key decisions about the procedures and rules of making those decisions, etc.

In addition:

- profit may not be the sole and a key measure of assessing the condition of the company,
- Profit is an internal goal,
- Gain a synthetic indicator does not show the impact of various factors on the level,

the impact of such negative phenomena as the loss of loyal customers, the best suppliers, reducing the value of the brand, or reacts to them too late
• Profit is susceptible to manipulation accounting.

Although the traditional approach to profit maximization as the overriding purpose of the company, which is based on the interests of owners and is consistent with the principles of market economy, is facing criticism, but many places in literature (in terms of theoretical and practical) is devoted to issues of managing earnings.

EARNINGS MANAGEMENT – LITERATURE REVIEW

Potential earnings management has become a concern throughout the world.
Most of the prior studies on earnings management have focused on why firms manage earnings. Earnings management incentives originate from diverse reasons including:

- income smoothing (Moses, 1987; Yoon and Miller, 2002b),
  More specifically, earnings smoothing includes two metrics: the variability of the change in net income, and the variability of change in net income over the variability of change in cash flow from operations. A high variability is consistent with less earnings smoothing (Lang et al. 2003, 2006; Leuz et al. 2003; Ball & Shivakumar 2005, 2006; Barth et al. 2008; Christensen et al. 2008)[1],
- management compensation (Healy, 1985; Gaver et al., 1995; Holthausen et al., 1995),
- ownership control (DeAngelo,1986, 1988; Perry and Williams, 1994),
  Prior research has found that managerial ownership is associated with lower levels of earnings management (Dhaliwal et al., 1982),
- equity offerings (Loughran and Ritter, 1995; Loughran and Ritter, 1997; Rangan, 1998; Teoh et al.,1998; Yoon and Miller, 2002a),
- maximization of earnings-based compensation (e.g., Healy 1985),
- avoidance of debt-covenants violation (e.g., DeFond and Jiambalvo 1994),
- to manipulate earnings to avoid losses (Burgstahler and Dichev 1997)[2]

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[1] H. Chen, Q. Tang, Y. Jiang, Z. Ling,The Role of International Financial Reporting Standards in Accounting Quality: Evidence from the EuropeanUnion. Journal of International Financial Management & Accounting, Volume 21 Issue 3 (Autumn 2010), pp. 1-58.

[2] Burgstahler and Dichev (1997) present two theories that can explain loss avoidance (and earnings decrease avoidance). First, their transactions costs theory predicts that stakeholders, such as customers, suppliers, short-term creditors, and employees, use heuristic cut-offs at zero earnings or zero earnings changes to value their implicit claim on the firm and to determine the terms of transactions with the firm. As a consequence, the firm manipulates reported earnings beyond such cut-offs to improve its terms of transactions (see also Bowen, DuCharme, and Shores 1995). Second, prospect theory indicates that when individuals' wealth is at risk, they tend to evaluate potential wealth changes in reference to their current wealth, and attach a higher disutility to an actual decrease in wealth than to a foregone increase in wealth (Kahneman and Tversky 1979). In the research setting of Burgstahler and Dichev (1997), it is the value of shareholders' and creditors' explicit claim on the outcomes of the firm that is at risk. Shareholders and creditors who use accounting earnings to estimate the change in the value of their claim on the firm (economic performance), may experience higher disutility from an accounting loss of one dollar than they experience utility from an accounting profit of the same amount. As a consequence, shareholders and creditors may be averse to (small) accounting losses, if they perceive these losses to be persistent.
L.Coppens E. Peek , An analysis of earnings management by European private firms Journal of International Accounting, Auditing and Taxation Volume 14, Issue 1, 2005, pp. 1-17.

They find that firms appear to manipulate earnings to avoid losses and earnings decreases as there is a higher than expected frequency of firms reporting slightly positive earnings changes and a lower than expected frequency of firms reporting small decreases in earnings.

- political costs (Liberty and Zimmerman,1986; Jones, 1991; Cahan, 1992; Maydew, 1997; Han and Wang, 1998).

A number of academic studies have argued that earnings management may be beneficial because it potentially enhances the information value of earnings. Managers may exercise discretion over earnings to communicate private information to stockholders and the public (Subramanyam, 1996; Watts and Zimmerman, 1986; Healy and Palepu, 1993; Guay, Kothari, and Watts, 1996; Demski, 1998; Arya, Glover, and Sunder, 2003). If this is the case, then, earnings management may not be harmful to the stockholders and the public. In fact, the empirical evidence in Subramanyam (1996) supports the contention that managers exercise their discretion to improve the ability of earnings to reflect fundamental value. Other studies, nevertheless, argue in favor of the opportunistic use of earnings management (Healy and Palepu, 1993, for instance). Misalignment of managers' and shareholders' incentives could induce managers to use the flexibility provided by the Generally Accepted Accounting Principals (GAAP) to manage income opportunistically, thereby creating distortions in the reported earnings. Thus, earnings management can be viewed as either opportunistic or beneficial[3].

Some studies take a more general approach by investigating whether under all circumstances managers have an incentive to exceed certain thresholds, such as prior year earnings (Burgstahler and Dichev 1997; Degeorge, Patel, and Zeckhauser 1999). These studies find that managers are inclined to manage earnings upward when this would lead to earnings that are just above the thresholds, while previously being below these thresholds.

Burgstahler and Eames (1998) suggest that managers tend to report earnings that meet or beat analyst estimates. It is found that there is a psychological distinction between positive and negative numbers (or zero). Individuals usually form a negative perception when they see negative reported earnings; hence it is important to report positive profits to avoid unfavorable perceptions. A drop in reported earnings that are benchmarked against past year's performance will give a negative signal to the investors, thus it is equally important for the firm to sustain its recent performance. By meeting analysts' consensus forecast, firms are considered to be meeting the industry norm, as well as having comparable performance against other firms in the same industry.[4]

Earnings management may take the form of either income-increasing or income-decreasing accounting choices.

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[3] Jiraporn, Pornsit & Miller, Gary A. & Yoon, Soon Suk & Kim, Young S., 2008. Is earnings management opportunistic or beneficial? An agency theory perspective, International Review of Financial Analysis, Elsevier, vol. 17(3), pp. 622-634.

[4] Ch. Charoenwong, J. Pornsit, Earnings Management to Exceed Thresholds: Evidence from Singapore and Thailand, 2008 Electronic copy available at: http://ssrn.com/abstract=1104523.

Under certain conditions, managers may prefer to engage in income *decreasing* earnings management. Healy (1985), Gaver et al. (1995) and Holthausen et al. (1995) report evidence of income-decreasing accounting choices when managers' accounting-based bonuses are at their maximum. Several explanations for these income-decreasing accounting choices have been suggested. One possibility is that managers prefer to shift abnormal positive earnings forward in order to make future thresholds easier to attain. Another possibility is that managers are reluctant to report large gains because of fears that their performance target will be ratcheted up in the future. If downward manipulation imposes significant costs on external parties, boards should be as concerned with income-decreasing manipulations as they are with income-increasing earnings management[5].

Without any doubt, it looks different approach to earnings management in healthy than distressed companies. Due to the timeliness of the issue of global crisis further part of the considerations will be concentrated among the issues the earnings management of distressed companies.

Recent studies show, that generally during recession or crisis, companies generatelower financial result compare to economic expansion. Earnings is sensitive to the business cycle.

In particular, the Earnings Response Coefficient (ERC) has been shown to be higher during economic expansions than during contractions (Johnson, 1999). This result can be largely explained by the defining characteristic of macroeconomic expansion – broad-based economic growth. Furthermore, expansions are typically longer and thus more persistent than contractions. The higher growth and persistence associated with macroeconomic expansions alter the contextual expectations related to reported corporate earnings, resulting in a higher ERC[6]

There are a number of reasons to believe that conditional earnings conservatism is higher during periods of economic recession:

- securities litigation typically occurs following economic declines, when events such as sharp declines in stock prices are more likely. To address the heightened litigation risk during economic contractions, firms generally report more conservatively.
- the threat of increased regulatory scrutiny, resultant from more public uncertainty about the existence and impact of hidden bad news, arguably motivates the reporting of conservative accounting numbers. During such periods of uncertainty and heightened interest in information about bad news, regulators tend to respond with increased scrutiny.
- firms normally prefer internal sources of funding to external sources, and of the external sources, debt over equity financing. This is the result of adverse selection and increased information costs associated with obtaining external financing, especially as it relates to equity financing

[5] K.V. Peasnell, P.F. Pope, S. Young. Board Monitoring and Earnings Management: Do Outside Directors Influence Abnormal Accruals? Journal of Business Finance & Accounting.Vol 32/2005, pp. 1311-1346.

[6] D. S. Jenkins, G. D. Kane and U. Velury.Earnings Conservatism and Value Relevance Across the Business Cycle Journal of Business Finance & Accounting, 36(9) & (10), 1041–1058, November/December 2009, pp. 1041-1057.

Prior studies suggest that the management of firms in distress may have various incentives or feel pressure to manage financial information in different ways. The literature provides mixed results with regard to the earnings behaviour of distressed firms. Some studies find that the management of financially distressed firms adjusts earnings upwards (DeFond and Jiambalvo, 1994; Rosner, 2003; Beneish *et al.* 2004) while other studies show that the earnings of such firms are shifted downwards (DeAngelo *et al.*, 1994)[7].

Management of distressed firms has motivation (acting on behalf of shareholders or institutional investors) to report higher earnings in order to avoid debt covenant violations and probable bankruptcy. In such cases managers are primarily concerned with the short-term survival of their firm (which does not necessarily imply self-interested manipulation). For instance, DeFond and Jiambalvo (1994) show positive unexpected accruals in the year prior to default, consistent with managers manipulating earnings to prevent default. Dichev and Skinner (2002) also provide evidence that managers take actions to avoid debt covenant violations. An alternative explanation is that management of financially distressed firms may manipulate earnings upwards out of self-interest for various reasons, such as to avoid management turnover during the distressed period, or temporarily inflate the market price to increase their compensation or gain from cashing stock-based compensation holdings[8].

Prior literature shows that earnings management of financially-distressed firms is mixed (Bradbury, 2007)– distressed firms may engage in income-increasing accruals manipulation to reduce the impact of negative signals from financial distress (Burgstahler & Dichev, 1997; DeFond & Jiambalvo, 1994; Sweeney, 1994), or engage in incomedecreasing accruals manipulation for renegotiating debt contracts with lenders (DeAngelo, DeAngelo, & Skinner, 1994; Saleh & Ahmed, 2005). Jaggi and Lee (2002) further argue that the choice of income-increasing (or -decreasing) is influenced by the severity of financial distress[9].

Financial disterss is often contected with debt. It is interesting how debt influence on earnings management. When debt is relatively high, managers have strong incentives to make accounting choices and reporting decisions that reduce the likelihood of possible debt covenant violations (Watts and Zimmerman, 1986).1 Opportunistic managers are more likely to use their financial reporting discretion because:

1. financial leverage frequently serves as a proxy for closeness to accounting-based covenant violations (Billett et al., 2007; Dichev and Skinner, 2002; Press and Weintrop, 1990; and Smith, 1993),
2. the cost of violating debt covenants is large (Beneish and Press, 1993).

Therefore, when debt is high, accounting numbers may not represent faithfully the underlying future economic performance because of the aggressive use of accruals to

[7] A. Charitou, N. Lambertides and L.Trigeorgis Earnings Behaviour of Financially Distressed Firms: The Role of Institutional Ownership ABACUS, Vol. 43, No. 3, 2007, pp. 271-296.

[8] A. Charitou, N. Lambertides and L.Trigeorgis Earnings Behaviour of Financially Distressed Firms: The Role of Institutional Ownership ABACUS, Vol. 43, No. 3, 2007, pp. 271-296.

[9] P. Cheng, W. Aerts, A. Jorissen, Earnings Management, Asset Restructuring, and the Threat of Exchange Delisting in an Earnings-based Regulatory Regime Corporate Governance: An International Review, 2010, 18(5), pp. 438–456.

manage earnings in an effort to avoid covenant violations (Sweeney, 1994; and DeFond and Jiambalvo, 1994)[10], [11].

Prior accounting literature (e.g., Leuz, Nanda, &Wysocki, 2003) shows that earnings management is a pervasive corporate phenomenon under particular market regulations. In order to meet a pre-determined earnings target, earnings management is often the first choice:

1. a firm's earnings manageability may be constrained on some occasions. For example, severe loss firms may not be able to manage accruals (such as credit sales) at full discretion if operations are partially discontinued or substantially reduced.
2. loss firms threatened by delisting risk are subject to stronger scrutiny from auditors and stock exchanges. For example, financial statements in the loss reversal year should receive an unqualified audit opinion.
3. Earnings management does not improve economic viability, and firms turning into profits through earnings management could easily move back to losses again in the near future. In this vein, distressed firms may opt to use alternatives to enhance operating performance: such as employee layoffs and asset restructuring activities[12],

Individual firms may have different incentives for earnings management. However, the tools that firms use in managing earnings can be systematically associated with the decomposition of total accruals.

PURPOSE AND METHODOLOGY OF RESEARCH

The article is a continuation of the analysis described in the study: Determinants of financial result in terms of a global crisis in small and medium-sized enterprises in Poland - an analytical approach, part I

This paper analyzes the determinants affecting level of financial results, for small and medium-sized enterprises used in our sample over the years 2006 to 2009. Particularly interesting seems to establish the factors that shape these financial results (profit or loss) enterprises under the conditions of the recent financial crisis. The study will cover Poland, chosen at random (the sample consists of 288 commercial companies). The collected data are a balanced panel, so it is possible to eliminate random fluctuations. These analysis are possible for a constant group of companies.Results obtained will attempt to verify hypothesis: in terms of financial crisis on the final level of financial results of small and medium-sized enterprises are the variables different from the classic, familiar with the science.

[10] The two conflicting perspectives of debt suggest that the relationship between debt financing and earnings quality is ultimately determined by the interactions of the positive and negative influence of debt.

[11] Aloke (Al) Ghosh and Doocheol Moon Corporate Debt Financing and Earnings Quality Journal of Business Finance & Accounting, 37(5) & (6), pp. 538–559, June/July 2010.

[12] P. Cheng, W. Aerts, A. Jorissen, Earnings Management, Asset Restructuring, and the Threat of Exchange Delisting in an Earnings-based Regulatory Regime Corporate Governance: An International Review, 2010, 18(5), pp. 438–456.

To test the hypothesis, research was be carried using out extensive literature and analysis will be applied to a model - panel models: a classical method of the smallest squares and fixed effects model.

The classic estimation by the smallest square method of the panel model is realized with the use of the following formula:

$$y_{it} = x_{it}\beta + v_{it}$$

where: y_{it} – endogenous variable,

x_{it} - exogenous variable (generally a vector of exogenous variables),

β - N -dimensional vector of structural parameters of the model,

v_{it} - total random error consisting of a totally random part ε_{it} and an individual effect u_i related to a specific "it" panel unit ($v_{it} = \varepsilon_{it} + u_i$) [Kufel, 2007].

In the smallest square estimation it is assumed that the index $i = 1,..., N$ signifies consecutive objects, whereas the index $t = 1,..., T$ stands for units of time. The estimation is permissible when there is no individual effect and the panel is treated as the cross-sectional data collection [Kufel, 2007].

Next the fixed-effects panel analysis in the following form was used:

$$y_{it} = x_{it}\beta + u_i + \varepsilon_{it}$$

where u_i - individual effect,

ε_{it} - pure random error.

In the fixed-effects panel model fixed individual effects are eliminated by averaging the model against time (t index).

Explanatory variable is the variable financial result (profit or loss) among the variables under consideration will be 30 variables (metrics and financial ratios), which will undergo an initial substantive and statistical verification

Qualities of application of research results - in a situation in which clearly would be able to get the determinants influencing the financial results and economic value added of small and medium-sized enterprises in Poland – during the recent financial crisis, it would give an opportunity for entrepreneurs to pay special attention to these factors and to influence the final shape built up the financial result. In the longer term, it is the financial result is the goal, or provide opportunities to achieve their development goals.

DESCRIPTION OF THE EXAMINED COMMUNITY

The first stage of the project involved panel data analyses using the least squares estimation method. Table 1 contains the results of the calculations, and graph 1 shows a normal Q-Q plot for the model. It has been found that during the great financial crisis, the majority of the determinants had a negative effect on profit at the small enterprises included in the research project, reducing the amount of profit. The strongest variables reducing the level of profit were as follows: (a) interest paid on loans and credit facilities and (b) loss on

business operations. The determinants that improved the level of net profit included operating profit and financial revenue. The model as developed must be considered only as an initial model to be used for further analyses, as it is not fully correctly conditioned. Although the basic parameters of the model are satisfactory, the normal Q-Q plot distribution is not appropriate. Although it is not a critical condition for the correctness of the model, model 1 cannot be considered as a fully satisfactory model.

Table 1: Estimation results of the panel analysis – classical method of the smallest square.

Model 1: Panel estimation – method of the smallest square
Dependent variable: net profit
Resistant standard errors (robust HAC)

Variable	Coefficient	Standard error	*t*-Student	*p-value*	Significance*)
const	-965,771	9825,51	-0,0983	0,92181	
y70	0,0507186	0,0151122	3,3561	0,00097	***
y110	-0,0189225	0,00941649	-2,0095	0,04603	**
y113	0,0635082	0,025819	2,4597	0,01488	**
y114	-0,0516411	0,0230364	-2,2417	0,02624	**
y119	0,414568	0,198462	2,0889	0,03817	**
y197	-0,324515	0,171207	-1,8955	0,05969	*
y200	0,317484	0,171132	1,8552	0,06526	*
y201	1,89586	0,400526	4,7334	<0,00001	***
y202	2,0275	0,377963	5,3643	<0,00001	***
y205	-1,33171	0,415901	-3,2020	0,00162	***
y210	-1,73515	0,302629	-5,7336	<0,00001	***
y216	-1,05856	0,379643	-2,7883	0,00589	***
y6	-0,591495	0,194723	-3,0376	0,00275	***
y39	0,0234505	0,0106518	2,2015	0,02901	**
y78	-0,0104427	0,0032354	-3,2276	0,00149	***

Total Sum of Squares = 1,7736e+012
R^2 = 0,99971
Adjusted R^2 = 0,99964
F (41, 174) = 14471,9 (p < 0,00001)

*) * significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.
Source: own work.

Where:
y2 fixed assets,
y6 other intangible assets,
y15 fixed assets under construction,
y38 current assets,
y39 inventory,
y70 cash and cash assets,
y78 share capital,

y84 previous years' profit (loss),
y98 long-term liabilities from other parties,
y104 short-term liabilities from related parties,
y110 loans and credit,
y113 loans and credit from contractors,
y114 loans and credit facilities maturing up to 12 months,
y118 liabilities arising from taxes, customs, national insurance and other benefits,
y119 payroll liabilities,
y190 other costs by type,
y197 the other operating costs,
y200 other operating costs,
y201 operating profit (loss),
y202 financial revenue,
y210 financial expenses,
y211 interest paid,
y216 profit (loss) on business operations.

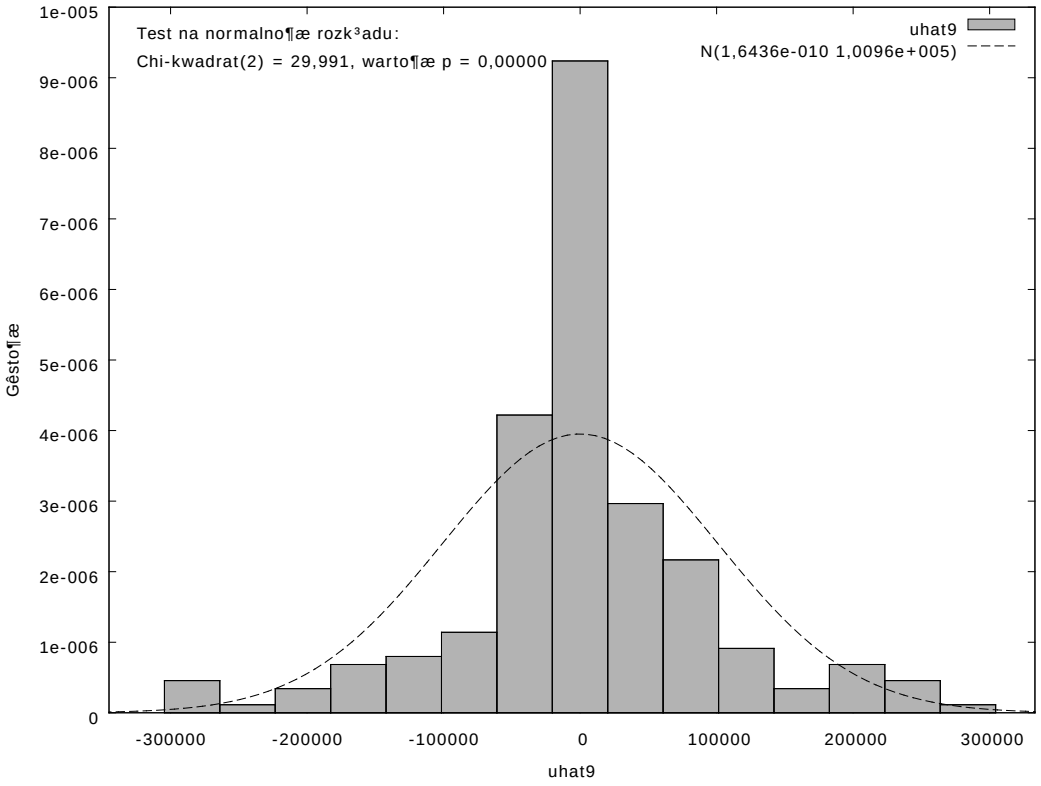

Figure 1: Normal plot of residuals for the model 1.
Source: own.

In order to achieve fully reliable results, panel data estimation was carried out, i.e. fixed effects estimation, and the results are shown in Table 2. In addition, figure 2 shows a normal Q-Q plot for model 2. The model covers a large number of the variables defined as net profit determinants in model 1. Note should be taken, as is the case of model 1, of the following variables: financial expenses, interest paid and loss on business operations. These variables significantly reduced the level of net profit. Variables that improved net profit include, in particular, the following: operating profit and financial revenue. The results achieved did not

allow for specifying “new” variables, but they did allow for confirming the common truths that the source of value growth for shareholders should be operation revenue and that additional benefits can be achieved by investing available cash in alternative portfolios (and not only in core business operations and fixed assets). The parameters of the model should be considered as satisfactory, and the normal Q-Q plot as close to normal, thus also acceptable. In order to verify the observations and whether or not the fact that the variables relate to a given period affects the final shape of the model, panel estimations (panel model with fixed effects) were carried out, taking into account a time variable. The results achieved are shown in Table 3 (the normal Q-Q plot is shown in figure 3).

Table 2: Estimation results of the panel analysis – panel model with fixed effects.

Model 2: Panel estimation – method with fixed effects
Dependent variable: net profit
Resistant standard errors (robust HAC)

Variable	Coefficient	Standard error	*t*-Student	*p-value*	Significance*)
const	-420944	129725	-3,2449	0,00158	***
y2	0,00670375	0,00203489	3,2944	0,00135	***
y15	0,0161985	0,00742004	2,1831	0,03130	**
y38	0,0109055	0,0043135	2,5282	0,01298	**
y70	0,0721854	0,0113101	6,3824	<0,00001	***
y84	-0,0660716	0,0206269	-3,2032	0,00181	***
y98	0,14662	0,0826953	1,7730	0,07918	*
y104	-0,0229831	0,0111882	-2,0542	0,04249	**
y110	-0,0598053	0,0105139	-5,6882	<0,00001	***
y113	0,0945454	0,0304501	3,1049	0,00246	***
y114	-0,11628	0,024809	-4,6870	<0,00001	***
y118	-0,219808	0,0437321	-5,0262	<0,00001	***
y119	-0,480582	0,135075	-3,5579	0,00057	***
y190	-0,198211	0,0929296	-2,1329	0,03531	**
y197	-0,290398	0,147678	-1,9664	0,05194	*
y200	0,249767	0,150342	1,6613	0,09969	*
y201	1,90984	0,31609	6,0421	<0,00001	***
y202	2,11072	0,323798	6,5186	<0,00001	***
y205	-1,42467	0,385928	-3,6916	0,00036	***
y210	-1,80391	0,238699	-7,5572	<0,00001	***
y211	-0,338364	0,185217	-1,8269	0,07062	*
y216	-1,04832	0,316198	-3,3154	0,00126	***

R^2 = 0,99995
Adjusted R^2 = 0,99960
F (112, 103) = 19901,4 (p < 0,00001)

*) * significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.
Source: own work.

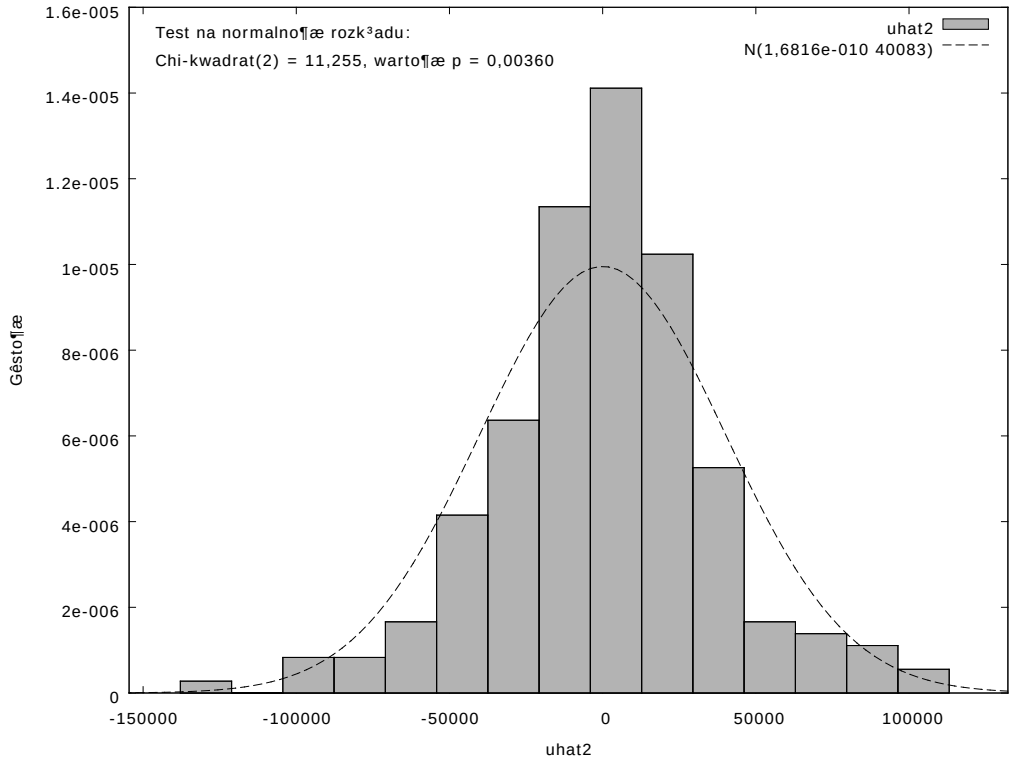

Figure 2: Normal plot of residuals for the model 2.
Source: own.

The results achieved allowed for confirming the earlier observations, and the final modelling effects were relatively slightly affected by the fact that the data related to the year 2008. It can therefore be expected that the middle year of the great financial crisis (2007-2009) was specific enough to affect the model, taking into account the financial results achieved by the group of enterprises included in the project. The parameters of the model should be considered as satisfactory, and the model as correctly conditioned, with a high degree of explanation of the process studied as part of the project.

Table 3: Estimation results of the panel analysis – panel model with fixed effects taking into account a time variable.

Model 3: Panel estimation – method with fixed effects
Dependent variable: net profit
Resistant standard errors (robust HAC)

Variable	Coefficient	Standard error	*t*-Student	*p-value*	Significance*
const	-435321	126763	-3,4341	0,00086	***
y2	0,00691576	0,00210773	3,2811	0,00142	***
y15	0,0166976	0,00742624	2,2485	0,02672	**
y38	0,0118643	0,00425756	2,7867	0,00636	***
y70	0,0720946	0,0113883	6,3306	<0,00001	***
y84	-0,0680601	0,0201926	-3,3706	0,00106	***
y98	0,161408	0,0847652	1,9042	0,05973	*
y104	-0,0227171	0,0100362	-2,2635	0,02574	**
y110	-0,0588719	0,0101474	-5,8017	<0,00001	***

y113	0,0945063	0,030746	3,0738	0,00272	***
y114	-0,118598	0,0249968	-4,7445	<0,00001	***
y118	-0,222575	0,044945	-4,9522	<0,00001	***
y119	-0,481218	0,128263	-3,7518	0,00029	***
y190	-0,182451	0,0915559	-1,9928	0,04898	**
y197	-0,290894	0,152259	-1,9105	0,05890	*
y201	1,89563	0,317326	5,9738	<0,00001	***
y202	2,09735	0,325261	6,4482	<0,00001	***
y205	-1,40873	0,387423	-3,6362	0,00044	***
y210	-1,79685	0,246522	-7,2888	<0,00001	***
y211	-0,315909	0,182196	-1,7339	0,08599	*
y216	-1,0319	0,317237	-3,2528	0,00155	***
dt_2	-16351,7	7618,7	-2,1463	0,03425	**
dt_3	-9559,19	9109,37	-1,0494	0,29651	

R^2 = 0,99995
Adjusted R^2 = 0,99990
F (114, 101) = 19654,8 (p < 0,00001)

*) * significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.
Source: own work.

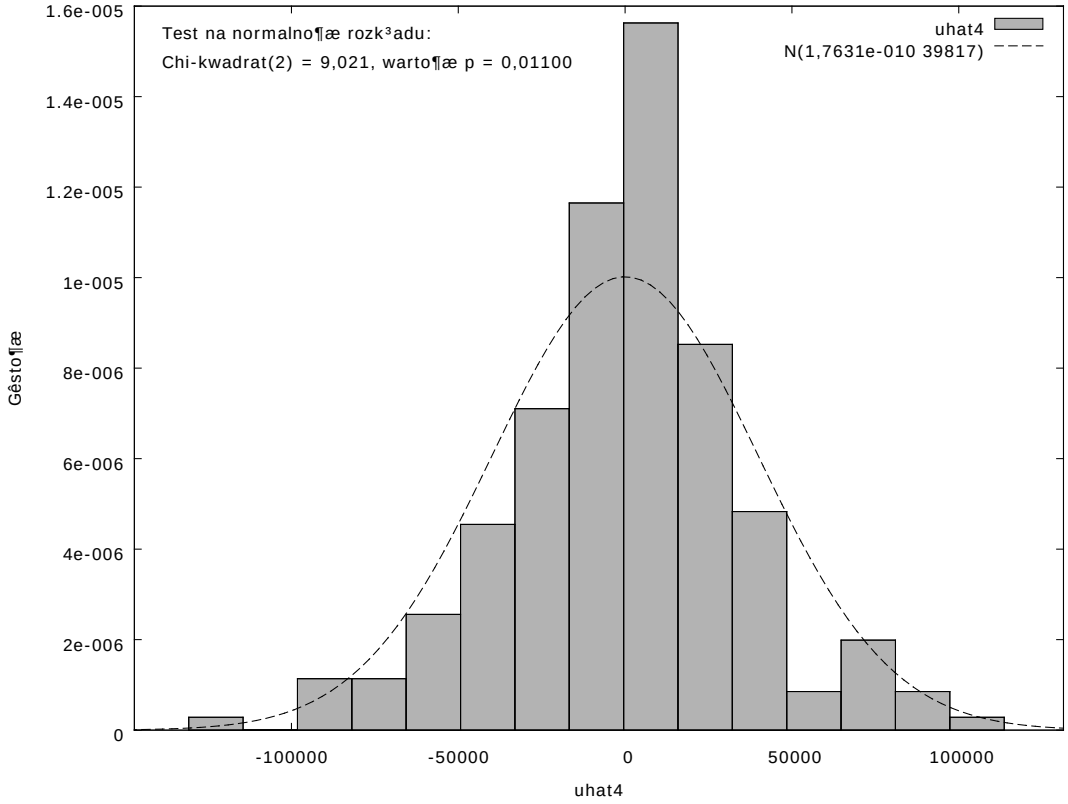

Figure 3: Normal plot of residuals for the model 3.
Source: own.

Small enterprises are a specific group of business entities. Therefore, an attempt was made to define the determinants affecting net profit using panel data estimation (random effects estimation). The results achieved are shown in Table 4. The analyses carried out confirm the significance of the determinants defined in models 2 and 3. However, model 4 is not correctly conditioned. As it can be seen from graph 4, the normal Q-Q plot is significantly different from the level that could be considered as close to normal. In order to verify whether or not the inclusion of a time variable improves the parameters of the model, panel data estimations (random effects) were carried out, taking into account a time variable. The results achieved are shown in Table 5.

Table 4: Estimation results of the panel analysis – panel model with random effects.

Model 4: Panel estimation – method with random effects
Dependent variable: net profit
Resistant standard errors (robust HAC)

Variable	Coefficient	Standard error	*t*-Student	*p-value*	Significance*)
const	-8755,99	12394,9	-0,7064	0,48087	
y2	0,00567957	0,00260709	2,1785	0,03071	**
y70	0,0576738	0,00937502	6,1519	<0,00001	***
y110	-0,0264198	0,00801269	-3,2972	0,00118	***
y113	0,0651298	0,0174373	3,7351	0,00025	***
y114	-0,0561579	0,0150685	-3,7268	0,00026	***
y118	-0,0917751	0,0322998	-2,8414	0,00503	***
y190	-0,0738379	0,0415275	-1,7780	0,07714	*
y197	-0,346064	0,0972337	-3,5591	0,00048	***
y200	0,336097	0,0975126	3,4467	0,00071	***
y201	2,01648	0,220369	9,1505	<0,00001	***
y202	2,17999	0,214126	10,1809	<0,00001	***
y205	-1,5202	0,212228	-7,1630	<0,00001	***
y210	-1,86736	0,209812	-8,9002	<0,00001	***
y216	-1,17519	0,214781	-5,4716	<0,00001	***
y6	-0,55727	0,122888	-4,5348	0,00001	***
y39	0,0173628	0,00910862	1,9062	0,05827	*
y78	-0,0099851	0,00330106	-3,0248	0,00286	***
y215	-0,249447	0,139886	-1,7832	0,07629	*

Akaike = 5640,72
Schwarz = 5782,48
Hannan-Quinn = 5697,99

*) * significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.
Source: own work.

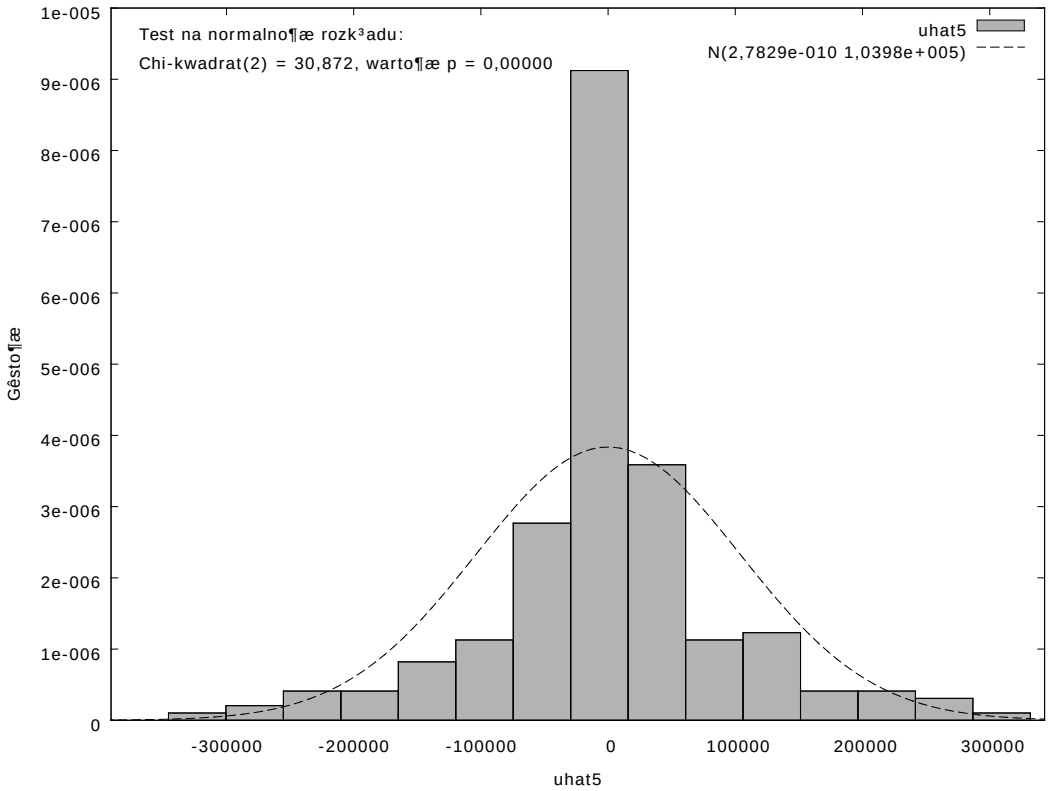

Figure 4: Normal plot of residuals for the model 4.
Source: own.

It is evident that the inclusion of a time variable did not significantly affect the determinants and their effect on the variable in question, i.e. net profit. Moreover, the d2_2 and dt_3 time variables were not statistically significant in the model. Additionally, this did not improve the parameters of model 5 (cf: the normal Q-Q plot – figure 5). It can therefore be stated that models 2 and 3 (fixed effects and fixed effects with a time variable) best describe the level of net profit achieved by small enterprises.

Table 5: Estimation results of the panel analysis – panel model with random effects taking into account a time variable.

Model 5: Panel estimation – method with random effects Dependent variable: net profit Resistant standard errors (robust HAC)					
Variable	Coefficient	Standard error	*t*-Student	*p-value*	Significance*
const	-9495,79	14707,5	-0,6456	0,51937	
y2	0,00559175	0,00264015	2,1180	0,03561	**
y70	0,057784	0,00944667	6,1169	<0,00001	***
y110	-0,0266434	0,00811966	-3,2813	0,00125	***
y113	0,0655139	0,0176457	3,7127	0,00028	***
y114	-0,0568687	0,0153271	-3,7103	0,00028	***
y118	-0,0934546	0,0327979	-2,8494	0,00492	***
y190	-0,0746482	0,0418408	-1,7841	0,07617	*
y197	-0,349864	0,0984677	-3,5531	0,00049	***

y200	0,339858	0,0987328	3,4422	0,00072	***
y201	2,027	0,223609	9,0649	<0,00001	***
y202	2,19051	0,21733	10,0792	<0,00001	***
y205	-1,5278	0,214937	-7,1082	<0,00001	***
y210	-1,88554	0,217595	-8,6654	<0,00001	***
y216	-1,18591	0,218158	-5,4360	<0,00001	***
y6	-0,560497	0,124147	-4,5148	0,00001	***
y39	0,0170801	0,00920235	1,8561	0,06516	*
y78	-0,00983882	0,00334981	-2,9371	0,00377	***
y215	-0,245254	0,141307	-1,7356	0,08442	*
dt_2	-871,616	15150,2	-0,0575	0,95419	
dt_3	4103,6	15987,5	0,2567	0,79774	

Akaike = 5644,98
Schwarza = 5793,5
Hannan-Quinn = 5704,98

*) * significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.
Source: own work.

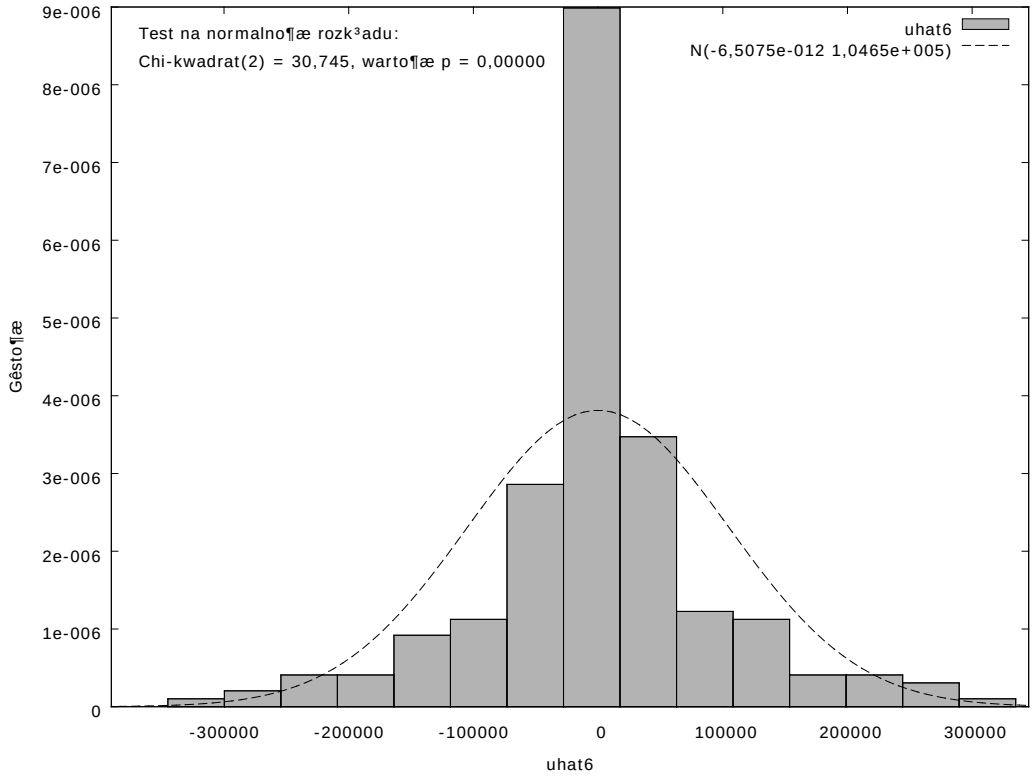

Figure 5: Normal plot of residuals for the model 5.
Source: own.

Findings of research

The results of the research allowed for defining net profit determinants at small enterprises during the great financial crisis. Determination of the factors that affect the level of net profit achieved by enterprises, particularly during a financial crisis, is of great practical significance. Knowing such factors, managers can include, in their decision-making processes, those variable which most significantly affect net profit levels achieved by enterprises.

SUMMARY AND CONCLUSIONS

1. It can be concluded based on the research that no such non-standard variables were observed during the great financial crisis which might significantly affect net profit levels achieved by small enterprises. Therefore, despite the difficult macroeconomic circumstances, managers continued to be interested in those areas which require special attention also under non-extreme conditions.
2. Those variables which had a particularly strong adverse effect on the level of net profit included interest paid on loans and credit facilities. Therefore, it is not advisable for small enterprises to take out debt during a financial crisis, as it may, in extreme cases, lead to the enterprise losing its financial liquidity and going bankrupt. The negative effect of incurring considerable financial expenses reflected in some of the enterprises included in the project recording losses on business operations. Because, in the opinion of the authors, profit/loss on business operations is that type of results which should be subject to in-dept analysis (as the level of net profit/loss on business operations depends, above all, on the managers/owners' decisions), this type of results should be given special attention during crisis years.
3. The determinants that positively affected the final results of the enterprises' operations were operating profit and financial revenue. This, therefore, confirms the common rule accepted in economics that special attention should be given to core business operations and that any other revenue should be considered as supplementary, particularly during crisis years. The positive effect of financial revenue shows that the managers were enterprising in their decisions and worked to generate additional benefits from alternative sources, in particular from bank term deposits.
4. It can be concluded based on the research that in the case of the enterprises included in the research project, the most appropriate method was panel data estimation (fixed effects panel models) and that the models developed best describe the process in question and are best conditioned.
5. Based on the model analyses conducted as part of the project, it can concluded that the "outstanding" year during the great financial crisis was the year 2008, and the fact that the variables related to the year 2008 was of significance in the final shape of the model. Therefore, in the group of enterprises included in the research project, special attention should be given to the variability of data between the years 2007-2008 and 2008-2009.

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SPATIAL ANALYSIS OF RISK VS. EFFICIENCY OF LIFE INSURANCE CONTRACTS[1]

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ABSTRACT

The main aim of the paper is to show the changes of the efficiency of life insurance by implementing the spatial analysis of death risk calculation. The death risk is differentiated by the regions of Poland. Such an aim involves answering the question of whether the application of regional death risk differentiation in the process of financial management can improve effectiveness of life insurance companies or rate of return of life insurance contract?

The above issue is explored on the basis of empirical research undertaken by the author. The research followed the pattern of premium differentiation for the whole life insurance by special so called profitability regions. The study is based on the demographic data which refers to the territory of Poland. The final stage is an approach to proof that the regional differentiation of an insurance rate (by spatial death risk analysis) has an improving effect on overall efficiency of an life insurance contract. That is checked by implementation of an approached provided by D. Moffet [2]who calculated effective rate of return on life insurance. Then the financial balance after insurance ends is calculated based on the regional risk analysis and the data concerning the risk in whole territory of Poland.

Keywords: life insurance, rates optimization, financial management,

INTRODUCTION

The economic processes taking place in Poland in recent years has affected also the broad insurance sector. The social and economic transformations, the break-up of monopolies and intensifying competition contributed to the development of business insurance. This is demonstrated by both the growing numbers of entities offering insurance products in the Polish market and the increase of the written premium. During the transformation the total life insurance market gross written premium has been rising by 36% annually.

Despite such strong growth, the Polish insurance sector is still lagging considerably behind the Western economies. While the Polish insurance market is generally believed to be in the growth stage, it is of particular significance given the integration of Poland with the economic system of the European Union. EU integration and the progressing globalization of financial services create a need for on-going monitoring and a revision of the current operating strategies, notably in their financial aspect. The continued development of the insurance sector is in the interest of the insurance companies operating in Poland. Insurance companies should seek to optimize their financial performance and to improve

[1] The research are financed by Polish National Science Center.

[2] D. Moffet, *An analysis of the Demand for Life Insurance: Mathematical Foundation*, The Journal of Risk and Insurance, Vol.46, No 2 (Jun 1979) pp.87-98

the flexibility of their insurance services to contribute to improving the financial standing of the insured businesses and households as well. This is possible by an on-going search for factors improving the competitiveness of businesses and increasing insurance awareness among the general public. This is a difficult challenge. One of the success factors is the ability to combine the efforts of the management teams of insurance companies with research findings.

The increasing attractiveness of the insurance market in Poland results in a rapid growth of competition. The tough competition forces insurance companies to take specific actions which should, above all, seek to improve flexibility via product and organizational innovation. The strong competition creates the need to look for ways to optimize the performance of insurers, and to develop on a continuous basis new insurance products that meet the needs of customers. The products should fully meet the needs of customers at the lowest possible insurance premiums. On the other hand the product should assure financial stability of insurance companies and ultimately ability to pay insurance claims. This is particularly important in the case of life assurance. The long-term nature of life assurance and the special nature of the attendant insurance risk (being the risk of death) render the financial management at insurance companies offering life assurance products highly difficult and complex. Each decision has specific ramifications for a period of several, or even a dozen or so, following years.

There are few publications, either in Poland or in the world, examining in detail the risk of death and the application of the findings in assurance processes. It is even more difficult to find sources explaining and demonstrating the effect of regional differentiation of insurance (rates) premiums on the financial management of insurance companies. Analyzing the literature of the subject it is possible to find some example of the similar studies. However it is not so popular. For example the approach to spatial analysis of death risk is described in the paper written by B. Babel, S. Eckel, R Schmidt and V.Schmidt, Mortality maps based on spatial extrapolation, working paper of University of ULM[3].

There are a number of researches that examine effect on different factors on the purchases of insurance product from costumer's side (life insurance demand determinants). However it is very difficult to find a study that examines the effect of regional differentiation on life insurance companies' profitability and effectiveness of life insurance by affecting insurance rates.

The main aim of the paper is to show the changes of the efficiency of life insurance by implementing the spatial analysis of death risk calculation. The death risk is differentiated by the regions of Poland. Such an aim involves answering the question of whether the application of regional death risk differentiation in the process of financial management can improve effectiveness of life insurance companies or rate of return of life insurance contract?

The above issue is explored on the basis of empirical research undertaken by the author. The research followed the pattern of premium differentiation for the whole life insurance by special so called profitability regions. The study is based on the demographic data which refers to the territory of Poland. The final stage is an approach to proof that the regional differentiation of an insurance rate (by spatial death risk analysis) has an improving effect on overall efficiency of a life insurance contract. That is checked by implementation of an approached provided by D. Moffetapproached provided by D. Moffetapproached provided by D. Moffet[4].

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[3] The full text of the paper is available at http://www.mathematik.uniulm.de/stochastik/personal/eckel/Publications/MortalityMaps20060131.pdf

[4] D. Moffet, *An analysis of the Demand for Life Insurance: Mathematical Foundation*, The Journal of Risk and Insurance, Vol.46, No 2 (Jun 1979) pp.87-98

METHODOLOGY AND DATA

The paper consist two main parts. In the first part the regions are merged into so- called profitability regions. That part consist the demographic analysis. To provide the study the demographic data are used. The database covers 16 Polish provinces (regions) and includes information about the population of regions in the years 1999 to 2003. For regions obtained the following data:

1. size of the population by individual age (from 0 to 100 years), separately for men and women;
2. number of deaths from regions (deaths in older and younger deaths by individual age from 0 to 100 years),
3. number of births in different regions.

Table 1 presents the summary of established regions taken together with their coding used by Polish Central Statistical Office.

Table 1: The codes and researched regions.

Code	Regions
D02	Dolnoslaskie
C04	Kujawsko-Pomorskie
L06	Lubelskie
F08	Lubuskie
E10	Ludzkie
K12	Malopolskie
W14	Mazowieckie
016	Opolskie
R18	Podkarpackie
B20	Podlaskie
G22	Pomorskie
S24	Slaskie
T26	Swietokrzyskie
N28	Warminsko-Mazurskie
P30	Wielkopolskie
Z32	Zachodniopomorskie

Source: Polish Central Statistical Office.

In the first stage there is an estimation of the frequency of deaths for the people aged from 5 to 84 years. The calculations were made separately for all studied regions. Age restriction stems from the fact that in the age ranges from 0 to 4 years we have a heterogeneous distribution of empirical probabilities of death. Thus in this age range processes, extinctions processes are difficult to theoretical modeling. The probabilities of death over the age of 84 years are extrapolated on the assumption of exponential function. In the presented studies frequency of death is used to characterize different regions. Narrowing the age range will not affect the importance of the achieved results and their interpretation from the perspective of optimizing the level of premiums for life insurance. The largest groups of life insurance customers are people in so-called production aged. The general conditions of insurance companies offer life insurance limit access to the upper age 65-70 years depending on the type of product and system of premium payment. Age of admission to life insurance contracts more than 65 years usually refers to the situation of one - installment of total premium, and it is associated

with the unit – linked life insurance products. Analysis of risk of death in the accepted age range, and the separation regions on the basis of a similar level of probability will correspond to the needs of life insurance companies.

Then after the calculation of frequency of death by individual ages and separately for the regions other variables were chosen to compare the regions by probability of death distribution. The comparison let to merge the regions in so-called profitability regions.
In order to identify the profitability regions cluster analysis were used. Cluster analysis was made separately for two moments in time. The first group was made for the implementation of features evaluated on the basis of data from the years 1998/1999. Then the analysis was repeated using the characteristics of the estimated value based on data from the years 2002/2003. This approach allowed the analysis of the changes that have occurred in the 5 years period. Segmentation was based on the Ward algorithm for 16 regions with 5 variables.

Used variables are:

1. the average age of people living in the region (Var1),
2. frequency of deaths in middle-aged people living in the region (Var 2),
3. parameter B of Gompertz function (Var 3)
4. parameter h of Gompertz function (Var 4),
5. participation of men in the average age in the total number of people in average age residing in the region (Var 5).

The results of the first part of the research are clusters which includes the regions that could be characterized by similar probability of death distribution. The results could be used by life insurance company to implement risk based pricing of life insurance contracts. The company could value the premiums separately for achieved profitability regions.
In the second part of the paper Moffet's approach is implemented to check if the risk based strategy influences the effective rate of return of life insurance contract.

CHOSEN VARIABLES – SHORT CHARACTERISTIC

Average age of the region's population

Average age is a variable chosen for the test. This variable was chosen because the distribution of the probability of death determines the level of that probability for a person at a given age. Average age was counted as a weighted average, where weights are the number of people living in the age of the region. Table 2 presents the results of calculations of average age in the different regions in the analyzed periods.

Table 2: The average age of population living in the region between 1999 and 2003.

No	Regions	Code	Average age		Difference	Change [%]
			1999	2003		
1.	Dolnoslaskie	D02	36	38	2	5,6%
2.	Kujawsko-Pomorskie	C04	35	36	1	2,9%
3.	Lubelskie	L06	36	37	1	2,8%
4.	Lubuskie	F08	35	36	1	2,9%
5.	Ludzkie	E10	38	39	1	2,6%
6.	Malopolskie	K12	35	39	4	11,4%
7.	Mazowieckie	W14	37	38	1	2,7%
8.	Opolskie	O16	36	37	1	2,8%
9.	Podkarpackie	R18	34	36	2	5,9%
10.	Podlaskie	B20	36	37	1	2,8%
11.	Pomorskie	G22	35	36	1	2,9%
12.	Slaskie	S24	36	38	2	5,6%
13.	Swietokrzyskie	T26	36	38	2	5,6%
14.	Warminsko-Mazurskie	N28	34	36	2	5,9%
15.	Wielkopolskie	P30	35	36	1	2,9%
16.	Zachodniopomorskie	Z32	35	37	2	5,7%

Source: Calculation done by the author based on data published by Polish Central Statistical Office.

In the period considered the average age increased in all regions analyzed. The largest increase, equal to 11.4% took place in the region of K12 (Malopolskie). In nine regions, the average age has increased more than 2%, but not more than 3%. The other six regions, the average age increased by more than 5%. The lowest average age change occurred in the region of W14 - Mazowieckie region. This may be due to the arrival of younger people in connection with the dynamically developing economy of the region, labor market and in total better prospects for the future.

Frequency of death

Second variable includes information about the number of people living and the dead at a given age. It is an estimator of the probability of death. The adopted frequency of death takes into consideration the information on the number of people who died in average age. This information is important for life insurance. The risk of death is the primary factor determining the level of insurance premiums. For the study the frequency of death counted on the basis of empirical data is used. Frequency comparisons were made for people in average age in the regions separately for two moments in time. Taking into account the characteristics of the distribution of probability of death is known that the level of the probability increases with age. For life insurance companies is important to have information about the direction and strength of changes in the frequency of deaths of people at any given age. Table 3 presents estimates of the frequency of deaths of people in average age, and changes in a given period of time for different regions.

Table 3: The frequency of death in average aged of population living in the regions between 1999 and 2003.

No	Region	Code	Frequency of death		Difference	Change [%]
			1999	2003		
1.	Dolnoslaskie	D02	0,00127	0,00115	-0,00012	-9,5%
2.	Kujawsko-Pomorskie	C04	0,00173	0,00154	-0,00019	-11,1%
3.	Lubelskie	L06	0,00179	0,00096	-0,00083	-46,4%
4.	Lubuskie	F08	0,00142	0,00176	0,00034	23,9%
5.	Ludzkie	E10	0,00298	0,00291	-0,00007	-2,3%
6.	Malopolskie	K12	0,00188	0,00231	0,00043	22,7%
7.	Mazowieckie	W14	0,00357	0,00092	-0,00265	-74,2%
8.	Opolskie	O16	0,00107	0,00139	0,00032	30,0%
9.	Podkarpackie	R18	0,00130	0,00138	0,00008	6,2%
10.	Podlaskie	B20	0,00135	0,00208	0,00073	54,1%
11.	Pomorskie	G22	0,00127	0,00158	0,00031	24,5%
12.	Slaskie	S24	0,00144	0,00202	0,00059	40,8%
13.	Swietokrzyskie	T26	0,00159	0,00094	-0,00065	-40,8%
14.	Warminsko-Mazurskie	N28	0,00114	0,00164	0,00050	44,4%
15.	Wielkopolskie	P30	0,00174	0,00155	-0,00019	-10,8%
16.	Zachodniopomorskie	Z32	0,00273	0,00187	-0,00086	-31,4%

Source: Calculation done by the author based on data published by Polish Central Statistical Office.

Analyzing the results shown in the table 3 it is visible that the level of death rates behaved differently depending on the region. In eight regions, there is a fall in the frequency of deaths in average age. The highest decrease was observed in the region W14 - Mazowieckie. In other regions, the frequency of death of people in average age increases. The highest increase was recorded in the region of B20 - Podlaskie.

Parameters of Gompertz law of mortality

Gompertz law of mortality [5]is based on the assumption of exponential distribution of probabilities of death. The law is based on the hypothesis of the so-called the human life force. Gompertz understood human life force as an inverse of the force of mortality (1 / μx (t)). He accepted that the loss of life force is proportional to the size of this force at any given time and the period in which the loss occurred. At the end he received the following formula:

$$\mu_x = Be^{hx} = Bc^x, \qquad (1)$$

where *B* and *h* are constant over the range of age considered. The parameter *B* determines the level of force of mortality of infants. However, the higher the value of the parameter *h* the force of mortality for the population is changing slower. Calculation of parameters may give rise to calculate force of mortality for separate Polish regions. Table 4 contains the estimates of Gompertz parameters of the exponential function (B, h) for all investigated regions separately. The analysis was based on

[5] The full description of Gompertz law of mortality could be found for example at: A. Neil, *Life contingencies*, Heinemann, London 1983, pp.27

demographic data from 1999 and 2003. This approach allows the assessment of changes in the force of mortality in regions within the period of 5 years. Estimates were based on the smoothed distributions of the probabilities of death in different regions. In order to smooth the empirical probabilities of death by individual ages moving average was used according to the Polish Central Statistical Office's methodology approach allows the assessment of changes in the force of mortality in regions within the period of 5 years. Estimates were based on the smoothed distributions of the probabilities of death in different regions. In order to smooth the empirical probabilities of death by individual ages moving average was used according to the Polish Central Statistical Office's methodology approach allows the assessment of changes in the force of mortality in regions within the period of 5 years. Estimates were based on the smoothed distributions of the probabilities of death in different regions. In order to smooth the empirical probabilities of death by individual ages moving average was used according to the Polish Central Statistical Office's methodology[6]

Table 4: Parameters of Gompertz law of mortality.

No	Region	Code	1999		2003		Change [%]	
			B	h	B	h	B	h
1.	Dolnoslaskie	D02	0,00020	0,0817	0,00010	0,0830	-50,00%	1,59%
2.	Kujawsko-Pomorskie	C04	0,00020	0,0814	0,00010	0,0838	-50,00%	2,95%
3.	Lubelskie	L06	0,00020	0,0793	0,00010	0,0827	-50,00%	4,29%
4.	Lubuskie	F08	0,00020	0,0814	0,00010	0,0842	-50,00%	3,44%
5.	Ludzkie	E10	0,00020	0,0805	0,00020	0,0815	0,00%	1,24%
6.	Malopolskie	K12	0,00020	0,0845	0,00020	0,0845	0,00%	0,00%
7.	Mazowieckie	W14	0,00030	0,0784	0,00010	0,0810	-66,67%	3,32%
8.	Opolskie	O16	0,00010	0,0839	0,00010	0,0743	0,00%	-11,44%
9.	Podkarpackie	R18	0,00010	0,0834	0,00010	0,0847	0,00%	1,56%
10.	Podlaskie	B20	0,00020	0,0785	0,00020	0,0796	0,00%	1,40%
11.	Pomorskie	G22	0,00010	0,0836	0,00010	0,0834	0,00%	-0,24%
12.	Slaskie	S24	0,00010	0,0840	0,00010	0,0853	0,00%	1,55%
13.	Swietokrzyskie	T26	0,00020	0,0791	0,00020	0,0804	0,00%	1,64%
14.	Warminsko-Mazurskie	N28	0,00020	0,0784	0,00020	0,0781	0,00%	-0,38%
15.	Wielkopolskie	P30	0,00020	0,0826	0,00010	0,0852	-50,00%	3,15%
16.	Zachodniopomorskie	Z32	0,00030	0,0793	0,00007	0,0857	-76,67%	8,07%

Source: Author.

Analyzing the above parameters of Gompertz function is visible that they differ in the regional section. For example, the parameter *B* for the region marked with the symbol Z32 is *0.0003* for the parameter *h* equal to *0.0793*. For the region D02 *B = 0.0002*, *h = 0.0817*. In 1993, the coefficient *B* takes three values equal to: *0.0001*, *0.0002* and *0.0003*. According to this parameter, all analyzed regions can be divided into three groups corresponding to three different values of the parameter. In 2003, you cannot see the value of *0.0003*.

Population structure

The share of middle-aged men in the total number of persons of the same age living in different regions were used due to the fact that the probability of death for men in that age is higher than the probability of death of women in the same age. This trend is visible by analyze the life expectancy tables on Polish territory. Table 5 compares the probability of death of selected age

[6] The methodology could be found at: *Life Table of Poland 2007*, GUS, Warsaw 2008, pp.34

group of men and women. The probabilities are estimated based on data from the year 2006 for whole territory of Poland.

Table 5: Comparison of probabilities of death for men and women in Poland.

Age	Probability of death		Difference
	Men (1)	Women (2)	(1-2)
15	0,00329	0,00122	0,00207
20	0,00537	0,00130	0,00407
25	0,00593	0,00147	0,00446
30	0,00822	0,00233	0,00589
35	0,01312	0,00412	0,00900
40	0,02187	0,00747	0,01440
45	0,03597	0,01288	0,02309
50	0,05531	0,02056	0,03475
55	0,07939	0,03084	0,04855
60	0,11021	0,04384	0,06637
65	0,15196	0,06437	0,08759

Source: Author.

Increased participation of men in total region population, due to higher probability of death would have negative impact from the perspective of life insurance company. Table 6 contains the estimated share of men in the population of polish regions.

Table 6: The share of middle-aged men in the total number of people living in the region at this age in the years 1999 and 2003.

No	Region	Code	Share [%]		Difference
			1999	2003	
1.	Dolnoslaskie	D02	50,15	50,69	0,54
2.	Kujawsko-Pomorskie	C04	49,72	50,05	0,33
3.	Lubelskie	L06	51,47	50,51	-0,96
4.	Lubuskie	F08	51,01	50,64	-0,37
5.	Ludzkie	E10	50,63	50,12	-0,51
6.	Malopolskie	K12	51,22	51,23	0,01
7.	Mazowieckie	W14	50,13	50,45	0,32
8.	Opolskie	O16	52,07	50,96	-1,11
9.	Podkarpackie	R18	51,19	50,40	-0,79
10.	Podlaskie	B20	50,95	51,21	0,26
11.	Pomorskie	G22	49,89	51,61	1,72
12.	Slaskie	S24	50,09	50,25	0,16
13.	Swietokrzyskie	T26	51,85	51,45	-0,40
14.	Warminsko-Mazurskie	N28	50,89	50,19	-0,70
15.	Wielkopolskie	P30	50,35	50,11	-0,24
16.	Zachodniopomorskie	Z32	51,53	51,00	-0,53

Source: Author.

The share of middle-aged men in the total number of persons in this age of regions varies around 50%. Comparing the shares in two periods, could be seen that the share has changed slightly. In the nine regions male participation has decreased, but increased in seven. The highest growth was recorded in the region G22 - Pomorskie. The decrease occurred in the region A16 - Opolskie.

SPATIAL ANALYSIS OF RISK OF DEATH AND THE SO-CALLED PROFITABILITY REGIONS

Cluster analysis was made separately for the two moments in time. The first grouping was made for the implementation of variables evaluated on the basis of data from the years 1998/1999. Then the analysis was repeated using the estimated value characteristics based on data from the years 2002/2003. This approach allowed the analysis of the changes that have occurred in the period of 5 years. Segmentation was based on the Ward's algorithm for 16 regions with 5 above described variables. Before cluster analysis all variables were standardized. Standardized values of variables for the years 1999 and 2003 are summarized in Tables 7 and 8.

Table 7: Values of the variables after standardization – 1999.

No	Region	Code	Variables				
			Var1	Var2	Var3	Var4	Var5
1.	Dolnoslaskie	D02	0,42444	-0,69190	0,20189	0,20266	-0,93721
2.	Kujawsko-Pomorskie	C04	-0,54571	-0,04596	0,20189	0,06755	-1,53759
3.	Lubelskie	L06	0,42444	0,03513	0,20189	-0,87818	0,90580
4.	Lubuskie	F08	-0,54571	-0,48218	0,20189	0,06755	0,26354
5.	Ludzkie	E10	2,36472	1,69470	0,20189	-0,33776	-0,26703
6.	Malopolskie	K12	-0,54571	0,16236	0,20189	1,46363	0,55674
7.	Mazowieckie	W14	1,39458	2,51679	1,81704	-1,28349	-0,96514
8.	Opolskie	O16	0,42444	-0,97432	-1,41325	1,19342	1,74353
9.	Podkarpackie	R18	-1,51585	-0,65135	-1,41325	0,96825	0,51486
10.	Podlaskie	B20	0,42444	-0,58144	0,20189	-1,23845	0,17976
11.	Pomorskie	G22	-0,54571	-0,69469	-1,41325	1,05832	-1,30023
12.	Slaskie	S24	0,42444	-0,46260	-1,41325	1,23845	-1,02098
13.	Swietokrzyskie	T26	0,42444	-0,24869	0,20189	-0,96825	1,43636
14.	Warminsko-Mazurskie	N28	-1,51585	-0,88064	0,20189	-1,28349	0,09599
15.	Wielkopolskie	P30	-0,54571	-0,03897	0,20189	0,60797	-0,65797
16.	Zachodniopomorskie	Z32	-0,54571	1,34377	1,81704	-0,87818	0,98957

Source: Author.

Table 8: Values of the variables after standardization – 2003.

No	Region	Code	Variables				
			Var1	Var2	Var3	Var4	Var5
1.	Dolnoslaskie	D02	-0,08979	-0,32404	0,03946	-0,40693	0,72628
2.	Kujawsko-Pomorskie	C04	-1,32121	-0,09912	0,03946	-0,16123	0,14175
3.	Lubelskie	L06	-0,70550	-0,43362	0,03946	-0,49906	0,56188
4.	Lubuskie	F08	-1,32121	0,02775	0,03946	-0,03839	0,68061
5.	Ludzkie	E10	0,52592	0,69098	2,74521	-0,86760	0,20569
6.	Malopolskie	K12	0,52592	0,34495	2,74521	0,05374	1,21947
7.	Mazowieckie	W14	-0,08979	-0,45669	0,03946	-1,02115	0,50708
8.	Opolskie	O16	-0,70550	-0,18563	0,03946	-3,07881	0,97288
9.	Podkarpackie	R18	-1,32121	-0,19140	0,03946	0,11517	0,46142
10.	Podlaskie	B20	-0,70550	0,21230	2,74521	-1,45111	1,20121
11.	Pomorskie	G22	-1,32121	-0,07605	0,03946	-0,28408	1,56653
12.	Slaskie	S24	-0,08979	0,17770	0,03946	0,29944	0,32442
13.	Swietokrzyskie	T26	-0,08979	-0,44515	2,74521	-1,20542	1,42040
14.	Warminsko-Mazurskie	N28	-1,32121	-0,04145	2,74521	-1,91178	0,26962
15.	Wielkopolskie	P30	-1,32121	-0,09336	0,03946	0,26872	0,19655
16.	Zachodniopomorskie	Z32	-0,70550	0,09119	-0,77227	0,42228	1,00941

Source: Author.

Dendrograms showing the final results of the segmentation procedures are presented on the next page.

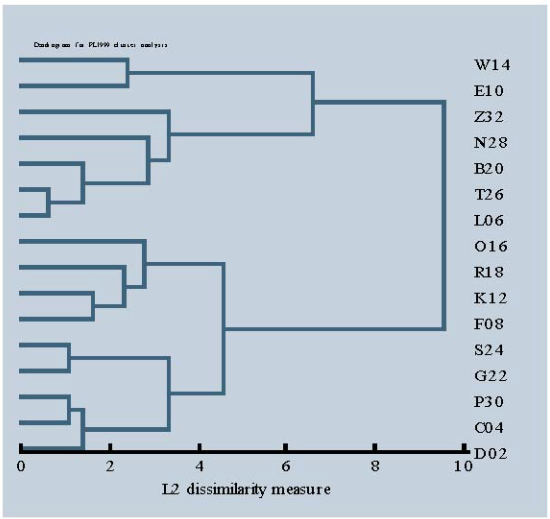

Figure 1. Clusters for the regions – 1999
Source: Author.

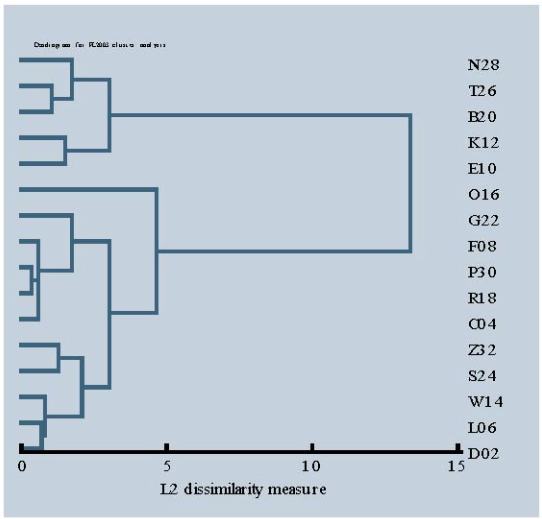

Figure 2. Clusters for the regions – 2003
Source: Author.

There has been a change in the similarity of the regions due to the value of the analyzed variables within the period of 5 years. Presented clusters differ. The allocation of regional groups (clusters) has changed in the period under review. For example, at the level of similarity measure equal to 6 in 1999 is subdivided into three clusters. With the same similarity measure in 2003, the regions can be grouped into two clusters. Extracted at a fixed level of similarity measurement areas (clusters) and regions belonging to them are summarized in Table 9. The extracted regions could be characterized by different risk of death. Therefore life insurance companies might implement the proposed approached to risk based pricing strategy. However before the implementation the influence has to be proved. If there is an influence on overall profitability of life insurance contract the regions could be so-called profitability regions. To show the possible effect of regional risk differentiation on the life insurance contract effectiveness Moffet approach is used. The results are shown and described in the next section of the paper.

Table 9: Grouped regions.

No	Regions	Code	Regions	Code
	1999		2003	
	Cluster I		**Cluster I**	
1.	Mazowieckie	W14	Warminsko-Mazurskie	N28
2.	Lodzkie	E10	Swietokrzyskie	T26
	Cluster II		Podlaskie	B20
1.	Zachodniopomorskie	Z32	Malopolskie	K12
2.	Warminsko-Mazurskie	N28	Lodzkie	E10
3.	Podlaskie	B20	**Cluster II**	
4.	Swietokrzyskie	T26	Opolskie	O16
5.	Lubelskie	L06	Podlaskie	G22
	Cluster III		Lubuskie	F08
1.	Opolskie	O16	Wielkopolskie	P30
2.	Podkarpackie	R18	Podkarpackie	R18
3.	Malopolskie	K12	Kujawsko-Pomorskie	C04
4.	Lubuskie	F08	Zachodniopomorskie	Z32
5.	Slaskie	S24	Slaskie	S24
6.	Podlaskie	G22	Mazowieckie	W14
7.	Wielkopolskie	P30	Lubelskie	L06
8.	Kujawsko-Pomorskie	C04	Dolnoslaskie	D02
9.	Dolnoslaskie	D02		

Source: Author.

EFFECTIVE RATE OF RETURN OF LIFE INSURANCE CONTRACT

The characteristic of distribution of probability of death was used as a general factor of merging regions. However, Moffet proved that the effective rate of return on life insurance seen to be related to the consumer's subjective probability of survival. There is an obvious relation between probability of death (q) and the probability of survival (p) where q=1-p. Moffed in his research introduced new approach to the topic of life insurance based on matrix analysis. The life insurance contract [7]in the year t_{th} could be written as the following vector:

$$[P+V_{t-1},Q,V_t], \qquad (2)$$

where:
P- premium,
Q – face amount,
V_t – cash value available at the end of the t_{th} year.
Application of the *principal of equivalence*[8] yields the following expressions for the effective rate of return r_t:

[7] D.Moffet, *An analysis of the Demand for Life Insurance: Mathematical Foundations*, The Journal of Risk and Insurance, Vol. 46, No.2 pp.96

[8] The paradigm of traditional life insurance is the so-called principle of equivalence, which is based on the notion of risk diversification in a large portfolio under the assumption that the future development of interest rates and other relevant economic and demographic conditions are known.

$$r_t = \left[\frac{(1-p_t)Q + p_t V_t}{P + V_t} - 1 \right] (100) \quad , \qquad (3)$$

where:

p_t – policyholder survival probability in the year *t*. Using the above formula probability in the year *t*. Moffet calculated the rate of return on an example of the $10.000 whole life insurance policy issued for a male age 22, at an annual premium of $101. The rate of return is sensitive to the probability of survival. The same example is used to show the influence of the probability of survival calculated separately for polish received clusters. The results are shown in table 10.

Table 10: Rate of return for received clusters – 2003.

t	V_t	p_t	r_t (%)	Cluster I		Cluster II		Difference
				p_t	r_t(%)	p_t	r_t (%)	
1	0	0,99814	-81,6%	0,99884	-88,5%	0,99892	-89,3%	0,8%
2	0	0,99811	-81,3%	0,99880	-88,1%	0,99888	-88,9%	0,8%
3	0	0,99809	-81,1%	0,99877	-87,8%	0,99884	-88,6%	0,8%
4	0	0,99807	-80,9%	0,99875	-87,6%	0,99881	-88,2%	0,7%
5	60	0,99804	-21,3%	0,99872	-28,0%	0,99877	-28,5%	0,5%
6	150	0,99801	5,3%	0,99868	1,2%	0,99872	1,0%	-0,3%
7	250	0,99797	7,5%	0,99862	5,0%	0,99866	4,8%	-0,2%
8	360	0,99792	8,3%	0,99854	6,6%	0,99858	6,5%	-0,1%
9	460	0,99787	4,2%	0,99842	3,0%	0,99848	2,9%	-0,1%
10	570	0,99781	5,3%	0,99829	4,5%	0,99836	4,4%	-0,1%
11	680	0,99775	4,5%	0,99814	3,9%	0,99823	3,8%	-0,1%
12	790	0,99763	3,9%	0,99796	3,6%	0,99808	3,4%	-0,1%
13	910	0,99760	4,6%	0,99776	4,4%	0,99790	4,3%	-0,1%
14	1030	0,99749	4,1%	0,99755	4,1%	0,99770	3,9%	-0,1%
15	1160	0,99736	4,6%	0,99731	4,7%	0,99748	4,5%	-0,1%
16	1280	0,99720	3,4%	0,99705	3,5%	0,99723	3,4%	-0,1%
17	1420	0,99699	4,7%	0,99678	4,8%	0,99694	4,7%	-0,1%
18	1550	0,99675	3,7%	0,99647	3,9%	0,99663	3,8%	-0,1%
19	1690	0,99647	4,1%	0,99614	4,3%	0,99628	4,2%	-0,1%
20	1830	0,99616	3,9%	0,99578	4,1%	0,99589	4,1%	-0,1%

Source: D. Moffet. op.cit. pp.97 and own calculation for cluster I and cluster II.

In general the differences are not so significant however the rate of return varies by received clusters. The smaller probability of survival the higher rate of return. It could be seen that the rates are higher in terms of cluster I.

FINANCIAL BALANCE AFTER IMPLEMENTATION SPATIAL RISK ANALYSIS APPROACH

It should also be examined whether the level of rates resulted by the application of the proposed manner (spatial analysis of risk) may cause an increase in the efficiency of life insurance before the final verification of the main idea of the research. To do that the sample portfolio of mixed life insurance[8] is used. Insurance portfolio consists of a group of 10,000 men at the age of 55 years, the face value is $ 1,000. Contribution (premium) in the amount of $ 90 is payable at the end of each year. Death benefits shall be paid on December 31 each year. In the last year of insurance the value of the survival benefits resulting from multiplying the number of persons alive by the sum insured. The interest rate used for the calculation is 5%. To simplify the calculation there is no profit participation. The comparison was made by the prism of estimated fund in hand at the end of the duration of the insurance. This fund has a direct impact on the technical provision of the insurance

[8] Benefit is payable if the insured person reached the age of 65 years or died before that age. undertaking. Increase of the technical provision has direct impact on overall financial results (net profit) of insurer. The increase of both technical provision and net profit has an impact of profitability ratio. As a result the changes of profits influence overall effectiveness of insurance activity. On the other hand, the insurer may reduce its premiums without any interference of solvency. In that case the operation part of activity of insurer is not so effective however the insurer may gather more capital (by intensifying sales level) to invest and at the end generate more capital income. Estimated fund's values in terms of separated clusters and whole territory of Poland are shown in table 11.

Table 11: The value of the fund remaining after life insurance (mixed) for a sample portfolio (10,000 men at the age of 55 years old).

No	Profitability region	Value of the fund [PLN]
1.	Cluster I	628.543
2.	Cluster II	637.433
3.	Comparison fund*	379.777

Source: calculation done by the author,
*fund remaining after endowment insurance ends provided in a sample described by E.Stroiński, *op.cit…*, LAM&E.Stroiński, Warszawa 1996, s.110, the fund is calculated based on demographic data concerning all territory of Poland

Spatial analysis of the risk of death and its application into the process of premium calculation could be the way of optimizing profits by life insurers. As could be seen from the summary presented in table 11, there has been a significant increase in the value of the fund remaining after endowment insurance ends. On the other hand there is a possibility of decreasing life insurance rates with no risk of losing financial stability and solvency. In the presented example (table 11) the reduction in rates by about 6% will result that the fund remained after the insurance is equal to 0 PLN. Such a range of possible reducing seems no very high however on the competitive market it could be a significant source of market competition.

CONCLUSIONS

The Polish life insurance industry has grown rapidly during the transition period. The changes concern almost all life insurance aspects, especially the level of competition. The number of companies rose more than eight times in comparison to 1991 when new reforms were implemented. Life insurance companies should constantly improve their competitiveness to attract more customers. The negative influence of financial crisis and the final loss of trust to life insurance companies also caused the need for new strategies of life insurers. One of the new approach to the costumers could be risk based pricing of life insurance contract. Currently life insurers differentiate premiums by sex. The results described in the paper proved that the premiums could also be differentiated by regions. However, first the demographic study is needed. There is no need to calculate premiums separately for each regions of particular country owe to the level of risk of death which is similar for some regions. Therefore, before the premium calculation the regions could be merged in to so-called profitability regions. Seem like cluster analysis is really useful to do that merging. However the variables chosen for the study are always disputable and the final result of merging depends on the kind of variables used to compare the regions. The main intention of the author of the paper was to show the possible direction for life insurers in terms of risk based pricing. Implementation of that approach also has an influence on the rate of return on life insurance and overall effectiveness of life insurance business activity. Hence the results of the study should be in a scope of interest of life insurers. There are also no legal limitations. According to polish insurance law insurance companies are obliged to collect statistical and actuarial data which might be used to calculate insurance premiums and eventually to the process of premium differentiation. Only the differentiation of the premium by pregnancy and maternity is

formally prohibited.

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F2 – Performance management

F2.1 **Efficiency of Finnish water works – Impact of governance model**
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F2.2 **The effect of internal controls adaptability on operating performance**
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EFFICIENCY OF FINNISH WATERWORKS – IMPACT OF GOVERNANCE MODEL

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ABSTRACT

Efficiency of water and sewage services has been studied worldwide for decades and it has also raised interest in Finland. Public authorities have deployed several different ways to organize these services, even in the national level. Governance of these models has also been distributed. Objective of this research is to find out if a governance model has an effect on the efficiency of waterworks in Finland. Data Envelopment Analysis (DEA) was used as a tool to measure the efficiency of 19 waterworks. The efficiency results were analyzed in a way to see possible differences between different governance models. Research results indicate some differences in efficiency levels between different governance models. These results are, however, only suggestive because of the small sample and different constraints encountered in the research process. This research was the first attempt to compare efficiency of waterworks' governance models in Finland and it should be used as a foundation for improved and perfected models in the future.

Keywords: efficiency, data envelopment analysis (DEA), waterworks

INTRODUCTION

Efficiency of waterworks has been studied worldwide for decades (Coelli & Walding, 2006; García-Sánchez, 2006; Thanassoulis, 2002). Efficiency has been very important issue when evaluating all kinds of productive activities, and research around the subject has produced a variety of evaluation techniques (Abbott & Cohen, 2009; Coelli, Rao, O'Donnell, & Battese, 2005; Corton & Berg, 2009). According to Abbot & Cohen (2009), the estimation of cost functions by various techniques has been the most commonly used method of determining the levels of efficiency in the water industry.

Efficiency of waterworks is a complex thing to be defined and consists of various "dimensions". There have been difficulties in getting comprehensive, comparable, and plausible results. The objective of waterworks is not to deliver as much water as possible, but rather to connect as many households as possible at efficient cost and quality. The general problems in measuring efficiency of water and sewage services concerns data quality issues such as differences in the valuation methods of capital, price deflators, influence of public funding and outsourcing of different activities (Coelli & Walding, 2006). The water sector is also characterized by a high degree of complexity

which requires a large number of observations while data availability is most often very restricted.

Currently there has been a growing interest towards the subject also in Finland. New governance models have been presented and implemented in many municipalities as an attempt to solve different problems, but has this helped to improve the overall efficiency of water and sewage services? The information about the ideal properties of waterworks would be very welcome to the decision-makers of water sector, because at the moment there are some presuppositions about the goodness or badness of the different governance models, but it is not possible to reliably state the differences between these models.

The objective of this study is to find out if the waterworks efficiency is related with waterworks' governance models. The goal is to see if there are differences in efficiency levels between the different governance models. The problem is defined and approached with help of the following research question: *Are there any differences in efficiency levels between waterworks different governance models?*

RESEARCH ENVIRONMENT

From 5.3 million inhabitants of Finland, more than 90% belongs to the water system and around 80% to the sewage system of Finnish waterworks (Silfverberg 2007). Arranging water and sewage services for municipal residents is the fundamental obligation of municipalities (Act on Water Services 119/2001). Municipalities (336 in 2011) are self-administrative units of the Finnish government. Waterworks are governed by the law in Finland if it delivers drinking water or receives sewage more than 10m³ per day, or serves more than 50 inhabitants and at the same time serves more than one property (Act on Water Services 119/2001). According to the statistical system for Finnish waterworks (VELVET), there are currently approximately 1500 water and sewage service providers in Finland. Most of the waterworks are extremely small, providing water only to few dozens or hundreds of customers. 25 largest municipal waterworks provide about 60% of the total amount of water sold in Finland (Kuntaliitto 2007).

According VELVET, the most common ownership and governance models in the Finnish water sector measured in number are respectively: private cooperative, municipal department (MD), municipal-owned enterprise (MOE), municipal-owned company (MOC) and federation of municipalities (FoM). In addition, there are hundreds of small water service associations and partnerships, which provide services to less than 50 people. According to the VELVET statistics, 222 of Finnish waterworks are organized as MDs, 54 as MOEs, 155 as MOCs and 886 as cooperatives. The rest of the roughly 1500 waterworks are organized as partnerships, limited partnerships and federations of municipalities.

Waterworks as a municipal department (MD) is an integral part of municipal organization. They are part of the municipal budget and investment program. MDs have a defined income source (user fees), but it can receive additional income transfers from the state or the municipality. (Heikkinen, Tapio, Haikko, & Paloposki, 1996; Kähkönen, 1996) Reasons to include business activities, like waterworks, into municipality's budget can be e.g. temporary

financing of investments with taxes, avoiding extra costs that arise from creation of new administrative body, or keeping the pricing policy under political control (Myllyntaus, 2001).

Municipal owned enterprise (MOE) is a business unit, for which municipal council has defined the state of (financial) independence. Although MOEs are fully owned by the municipality, their budget is separated from municipality's budget and they have their own financial statement including profit and loss statement, balance sheet, and funds statement. Public ownership ensures that the municipality can reap the benefits of operations and at the same time have democratic control over the operations. (Heikkinen et al., 1996; Jalkanen et al., 1996; Kähkönen, 1996; Myllyntaus, 2001) Because MOE is part of the municipality it cannot go bankrupt and it is not tax liable when operating within the municipality's territory (Heikkinen et al., 1996).

Municipal owned company (MOC) is owned and controlled by one or several municipalities. It is a legal entity whose operations and management are regulated by Limited-liability Companies Act (624/2006). They operate as commercial businesses and do not have societal obligations like the MDs and MOEs. (Kähkönen, 1996) They can also be expected to make profit and to provide reasonable return on capital to the municipality (Jalkanen et al., 1996). MOC has its own budget, investment program and financial statement. MOC is subject to taxation at the tax rate on profit of 26 %. It is also liable to a property tax. MOCs can decide on investments independently and freely acquire financing from the financial markets. (Heikkinen et al., 1996)

A cooperative is owned by its members, who usually are the customers of the service. Cooperatives are thus communities by nature, and although they are running business operations, their main purpose is to support their members' welfare instead of sharing profit why cooperatives often operate on non-profit basis. Cooperative needs to comply with the Co-operatives Act (1488/2001) and they have the same tax on profit as the limited-liability companies, 26 %. In addition to loans provided by banks, financial institutions and insurance companies, the cooperatives can get financing from government and municipal subsidies. (Mynttinen & Taipale, 2007)

METHODOLOGY

Efficiency is often defined simply as *"the ratio of the output to the input of any system"* (Cooper et al., 2000). It means the amount of desired outcome that is produced with a certain amount of resources. When looking at the whole picture, typical approaches to efficiency tend to focus on subjects like cost reduction (reducing inputs), quality control (reducing waste), technology investment and time management (increasing productivity). The ultimate goal thereby is to reduce inputs, increase outputs, or both at the same time in order to improve profitability. (Witzel, 2002)

Some of the most commonly used dimensions of efficiency and their definitions are:

- *allocative efficiency:* refers to the responsiveness of service to public preferences (Leibenstein, 1966)

- *technical efficiency:* measures a firm's success in producing maximum output from a given set of inputs (Farrell, 1957; Leibenstein, 1966)
- *price efficiency:* measures a firm's success in choosing an optimal set of inputs (Farrell, 1957)
- *cost efficiency:* refers to the least amount of inputs used to produce a fixed level of output(s) at minimum possible cost (Coelli et al., 2002)
- *scale efficiency:* tells about the optimal size and scale of operations of an entity under efficiency analysis (Cubbin & Tzanidakis, 1998; Coelli et al., 2005).

In this research, Data Envelopment Analysis (DEA) was selected as a tool to measure the efficiency of waterworks. It has been used in various studies to measure waterworks' efficiency in different countries (Abbot & Cohen, 2009). As a non-parametric method, DEA concentrates on variations in performance among entities under comparison. It describes the subjects of efficiency evaluation as decision making units (DMU). These DMUs are thought to be any kind of entities, e.g. waterworks, that convert multiple inputs into multiple outputs, and the estimate of relative efficiency is derived from comparison of the ratios of total inputs used to total outputs produced by each DMU (Cooper et al., 2004). DEA uses linear programming techniques, which create an efficiency frontier that is used as a benchmark when comparing the DMUs with each other (Coelli et al., 2005). This frontier in a way "envelopes" the data leaving the measured efficiency values below the plotted curve in the graph (e.g. Cubbin and Tzanidakis, 1998).

In the case of single input and output, the *constant returns to scale (CRS)* assumption is based on thought that all observed production combinations can be scaled up or down proportionally. This kind of DEA model is named as CCR-model (due to Charnes, Cooper, and Rhodes, 1978) and it is one of the two most widely used DEA models together with BCC-model (due to Banker, Charnes, and Cooper, 1984). BCC-model uses *variable returns to scale (VRS)* assumption, which allows the returns to scale vary when observed production combinations are scaled up and down (i.e. it does not have to result in equivalent changes in efficiency level). (Cullinane et al., 2006)

As an example of these two assumptions, there are 6 points (A, B, C, D, E, and F) in Figure 1 representing 6 companies, which each has different combinations of one input and one output. The straight line from origin represents the efficiency frontier under *CRS* assumption and the piecewise line going via points A, B, C, D, and E forms the efficiency frontier under *VRS* assumption. Only the company C is *CRS*-efficient, but all the companies A, B, C, D, and E are *VRS*-efficient. When comparing the efficiency scores derived from both methods, it is possible to separate the effects of technical efficiency and scale efficiency and get information about their proportions. Let us take a look at company F, which is inefficient under both *CRS* and *VRS* assumptions. The input orientated technical inefficiency of the company F under the *CRS* is the distance FH, but under the *VRS* the same technical efficiency is only the distance FG, while the difference between these two, the distance GH, is considered as *scale inefficiency*. So at its current size, company F should improve its position at least to the point G, if it would like to become technically efficient under the *VRS* and further improvement would require changes in the company's size. (Cubbin & Tzanidakis, 1998; Coelli et al., 2005).

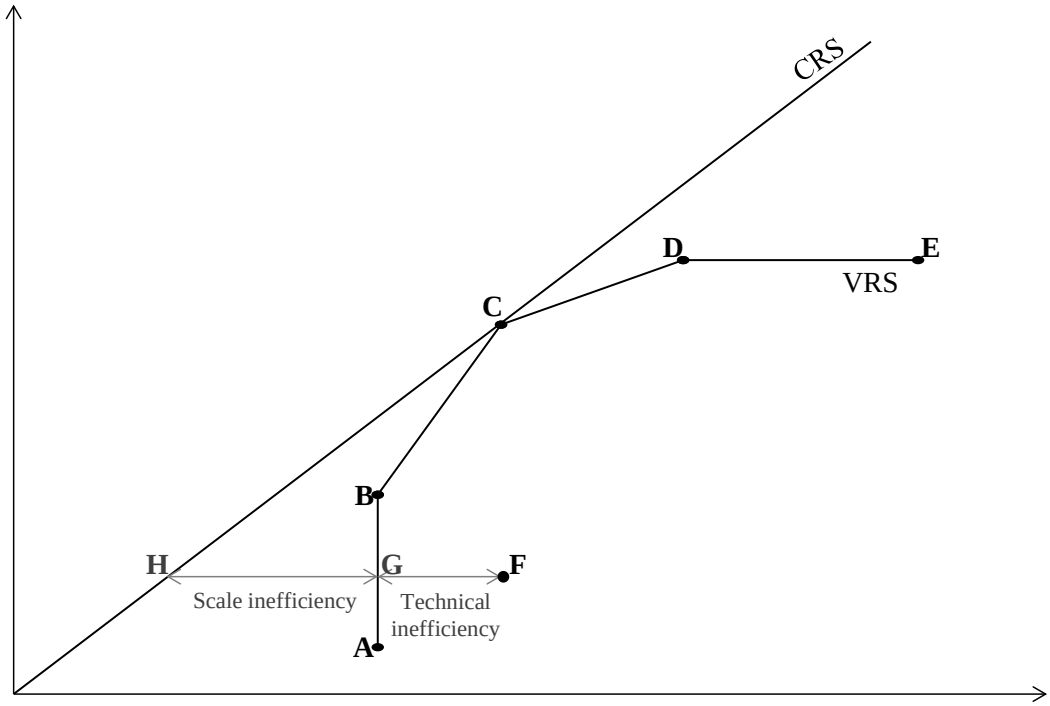

Figure 1: CRS vs. VRS, single input and single output example.

Input oriented CRS model

Assume there are data on *N* inputs and *M* outputs for each *I* firms. For the *i*-th firm these are represented by the column vectors $\mathbf{x}_i$ and $\mathbf{q}_i$, respectively. The *N*×*I* input matrix, **X**, and the *M*×*I* output matrix, **Q**, represent the data for all *I* firms. For each firm, a measure of the ratio of all outputs over all inputs is needed, let that be $\mathbf{u'}\,\mathbf{q}_i\,/\mathbf{v'}\,\mathbf{x}_i$, where **u** is an *M*×1 vector of output weights and **v** is a *N*×1 vector of input weights. (Coelli et al., 2005). The optimal weights are obtained by solving a mathematical programming problem:

$$\max_{u,v} (\mathbf{u'}\,\mathbf{q}i\,/\mathbf{v'}\,\mathbf{x}i),$$

subject to $\mathbf{u'}\,\mathbf{q}j\,/\mathbf{v'}\,\mathbf{x}j \le 1, \quad j = 1,2,\ldots,I,$

$\mathbf{u}, \mathbf{v} \ge 0.$ (1)

This involves finding values for u and v, such that the efficiency measure for the *i*-th firm is maximized, subject to the constraints that all efficiency measures must be less than or equal to one. The linear programming problem is solved for each of the *I* firms in the sample, so each of these firms is assigned a set of weights that are most favorable to them. One problem in this formulation is that it has infinite number of solutions. (Coelli et al., 2005). To avoid this, one can impose a constraint v' xi = 1, which provides:

$$\max_{\mu,v} (\boldsymbol{\mu'}\,\mathbf{q}i),$$

subject to $\mathbf{v'}\,\mathbf{x}i = 1,$

$\boldsymbol{\mu'}\,\mathbf{q}j - \mathbf{v'}\,\mathbf{x}j \le 0, \quad j = 1,2,\ldots, I,$

$\boldsymbol{\mu}, \mathbf{v} \ge 0,$ (2)

The change of notation from u and v to μ and v is used to stress that this is a different linear programming problem. The form of the DEA model in linear programming problem 2 is known as the multiplier form. (Coelli et al., 2005). Anyhow, the generally preferred form to solve this problem is called the envelopment form:

$$\min_{\theta,\lambda} \vartheta,$$

$$\begin{aligned} \text{subject to} \quad & -\mathbf{q}i + \mathbf{Q}\boldsymbol{\lambda} \geq 0, \\ & \vartheta \mathbf{x}i - \mathbf{X}\boldsymbol{\lambda} \geq 0, \\ & \boldsymbol{\lambda} \geq 0, \end{aligned} \qquad (3)$$

Here θ is a scalar and λ is a *I*×1 vector of constants. The value of θ obtained is the efficiency score of the *i*-th firm. The linear programming problem must be solved *I* times, once for each firm in the sample. A value of θ is then obtained for each firm. (Coelli et al., 2005).

Input oriented VRS model

In a case when the firms face imperfect competition, government regulations, constraints on finance etc. the *VRS* assumption is more appropriate, because the *CRS* assumption is mainly for situations where all firms are operating at optimal scale. To separate the effects of scale efficiency and technical efficiency, the *CRS* linear programming problem can be modified to account for *VRS* by adding the convexity constraint: $\mathbf{I}1'\boldsymbol{\lambda} = 1$ to equation 3 to provide:

$$\min_{\theta,\lambda} \vartheta,$$

$$\begin{aligned} \text{subject to} \quad & -\mathbf{q}i + \mathbf{Q}\boldsymbol{\lambda} \geq 0, \\ & \vartheta \mathbf{x}i - \mathbf{X}\boldsymbol{\lambda} \geq 0, \\ & \mathbf{I}1'\boldsymbol{\lambda} = 1, \\ & \boldsymbol{\lambda} \geq 0, \end{aligned} \qquad (4)$$

where **I**1 is an *I*×1 vector of ones. Technical efficiency scores provided by VRS are greater or equal to those provided by CRS, thereby the number of efficient firms is often higher in VRS. (Coelli et al., 2005).

Calculation of scale efficiency can be done by conducting both a *CRS* and a *VRS* DEA for all firms in the sample, and then decomposing the technical efficiency scores obtained from the *CRS* DEA into two components, one due to scale inefficiency and due to "pure" technical inefficiency. Figure 1 helped to explain the inefficiencies as distances, now let us take a look at how to express the technical and scale efficiencies as ratio measures. TE^{CRS} is technical efficiency given by *CRS*, TE^{VRS} is technical efficiency given by *VRS*, and SE is scale efficiency. (Coelli et al., 2005) These expressed as ratios from Figure 1 are the following:

$$TE_{CRS} = YH / YF$$
$$TE_{VRS} = YG / YF$$
$$SE = YH / YG$$

So the scale efficiency can be expressed as:

$SE = TE_{CRS} / TE_{VRS}$. (Coelli et al., 2005).

Finally, in order to know if the firm is operating in an area of increasing or decreasing returns to scale, one has to run an additional DEA problem with *non-increasing returns to scale (NIRS)* imposed. This is done by substituting the $\mathbf{I1'\lambda} = 1$ restriction in eq. 4 with $\mathbf{I1'\lambda} \leq 1$, to provide:

$$\begin{aligned} &\min_{\theta,\lambda} \vartheta, \\ &\text{subject to} \quad -\mathbf{q}i + \mathbf{Q\lambda} \geq 0, \\ &\qquad \vartheta\mathbf{x}i - \mathbf{X\lambda} \geq 0, \\ &\qquad \mathbf{I1'\lambda} \leq 1, \\ &\qquad \mathbf{\lambda} \geq 0, \end{aligned} \tag{5}$$

By comparing the inefficient firms' *VRS* technical efficiency scores with technical efficiency scores obtained with *NIRS*, one can determine the nature of returns to scale. If a firm has an equal technical efficiency (TE) score from both the *VRS* and *NIRS*, *decreasing returns to scale* exist for that firm, i.e. the firm could become more efficient by decreasing its size when the productivity of its inputs would increase. If TE scores from *VRS* and *NIRS* are unequal, *increasing returns to scale* apply and the company could improve efficiency by increasing its size again. (Coelli et al., 2005). In a case where scale inefficiency exists and the company is otherwise technically efficient, the efficiency improvement is achievable only through a change in the size of a company, or otherwise it cannot achieve the maximum productivity for its inputs (Jaforullah & Whiteman, 1999).

RESEARCH RESULTS

DEA model and explanation of its variables

The selection of the input and output variables that are to be included in a DEA model is a complicated exercise. Variables for this study were selected according to the previous waterworks efficiency evaluation studies which have used the DEA method. Different variables used in the past 20 years are listed by Abbot & Cohen (2009) and summarized in Table 1.

Table 1: Variables used in water sector DEA studies (summarized from Abbot & Cohen 2009).

INPUT variables	**OUTPUT variables**
personnel (numbers) / labour (p/t and f/t)	volume of water delivered
operating expenditure	number of properties connected/supplied
energy	population served
length of mains	length of mains
capital expenditure	annual water consumption
chemicals	sewage treated
other costs	potable water
materials	volume of delivered potable and non-potable water
specific wastewater treatment costs	physical amount of wastewater
proportion of water delivered to non-households	primary treatment
management cost	secondary treatment

maintenance and operation costs	analyses performed
capital replacement cost	number of assessments (services to properties)
outside services	average pumping head
groundwater, surface water, purchased water	average peak
treatment plants	size of area served
storage capacity	capacity of pumping
	water quality index
	water service index

In this research, DEA model by Coelli and Walding (2006) has been applied. They used operating and capital expenditures as inputs and number of properties connected and volume of water delivered as outputs. Figure 2 shows the variables used in this research.

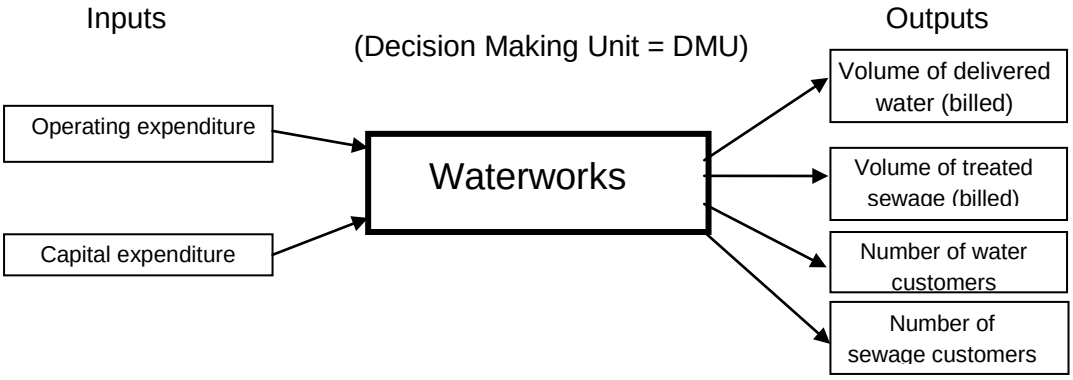

Figure 2: DEA model used in this study.

Operating expenditure variable as an input includes all operating costs of waterworks. It is formed by summing up the following income statement items: materials and supplies, change in stock value, outsourced services, wages and salaries, pension expenses, other indirect employee costs, and other operating expenses. *Capital expenditure* variable is formed by summing up the following income statement items: depreciations to plan and write-downs, interest expenses (all of them including interest expenditure to municipality, interest expenditure to others, income transfers to municipality), compensation for capital invested, and other financial expenses. Output variables include *volume of billed water, volume of billed sewage, number of water customers* and *number of sewage customers*.

The idea was to create a DEA model that takes into account both of the two dominating factors in the water industry, economies of scale and density (Walter et al., 2009). When the capital expenditure as input is related mostly to the network density (sparsely populated areas usually have higher amounts of pipeline capital relative to the operating costs), it should ensure that the waterworks with highly dense networks are benchmarked with other similar high density waterworks, low density firms with other low density companies etc. (Coelli & Walding, 2006). In addition, the capital costs of waterworks and the length of water and sewage mains are tied strongly together (Coelli & Walding, 2006), so instead of placing the "length of mains" as a variable, it was included in the model without excluding the capital costs caused by other sources in a similar way. The number of water and sewage service customers as an output together with the measures for two basic services water delivery and sewage treatment (which can be seen as the main tasks for any waterworks) is

also related to the scale of operations. The bigger the ratio of the capital costs to the number of customers is, the more sparse tend the network structure be as well.

Since one of the main goals of the study is the ranking of waterworks according to their efficiency, the total number of variables has to be kept low enough in order to avoid the loss of discrimination power the DEA method offers (Ajodhia et al., 2003; Tone & Tsutsui, 2009), because the comparison group is known to be relatively small.

Data collection and DEA solver program

The required data for the study is collected from the financial statements of the waterworks from the year 2008 (or the financial statement of a municipality in a case when the waterworks is operating as a municipal department). Choosing the financial statements as the primary source of data partly relates to the data quality requirement set by the DEA method. Common and tightly controlled rules for accounting are seen as the best insurance available against the errors in data. If all the necessary information was not found this way, the missing info was obtained from the waterworks' Internet pages or by asking directly from the waterworks themselves.

An efficiency analysis was carried out for a selected group of 19 waterworks (see Table 2). Waterworks from the most common ownership and governance models (municipal department, municipal owned enterprise, municipal owned company, and cooperative) were included in the study and for comparability all waterworks provide all core functions of water and sewage services (water acquisition and treatment, water delivery, sewage collection and sewage treatment). The results are analyzed so that the possible differences between different governance models efficiency can be identified.

Table 2: Size and governance models of waterworks included in the DEA analysis.

		Number of water customers		
		< 10000	10 000 - 60 000	> 60000
Municipal owned company (MOC)	MOC 1		X	
	MOC 2			X
	MOC 3			X
	MOC 4	X		
	MOC 5		X	
Municipal owned enterprise (MOE)	MOE 1		X	
	MOE 2			X
	MOE 3			X
	MOE 4			X
	MOE 5		X	
	MOE 6		X	
	MOE 7			X
Municipal department (MD)	MD 1	X		
	MD 2		X	
	MD 3	X		
	MD 4	X		
	MD 5		X	
Cooperative (COOP)	COOP 1	X		
	COOP 2	X		

The actual analysis has been carried out with the help of DEA solver program called Win4DEAP (version 1.1.2) which is developed by Michel Deslierres. The original DEAP program is written by Tim Coelli at the Centre for Efficiency and Productivity Analysis in University of New England. In final comparison, the input oriented model is selected along with the variable returns to scale assumption and DEA (multi-stage) calculation method. With these selections the program calculates the constant returns to scale (CRS) results also. This is important considering that under the variable returns to scale (VRS) assumption the inefficient waterworks are often benchmarked only against waterworks of similar size, but in a CRS DEA the waterworks can be benchmarked against substantially larger or smaller waterworks as well (Coelli et al., 2005).

Results

The final efficiency scores are shown in Table 3. The abbreviation crste means CRS technical efficiency under CRS assumption, vrste means technical efficiency under VRS assumption, scale means scale efficiency, and final column tells if the waterworks was considered to have increasing (irs) or decreasing returns to scale (drs) in its current situation. The crste scores compare all the waterworks with each other assuming that every one of them is able to reach the same efficiency level no matter their size. Vrste, instead, allow different levels of returns to scale occur, thereby resulting in better efficiency scores.

Table 3: DEA efficiency scores for reviewed waterworks.

Waterworks	crste	vrste	scale	irs/drs/-
MOC 1	0,954	0,968	0,986	drs
MOC 2	0,539	0,782	0,690	drs
MOC 3	0,834	1,000	0,834	drs
MOC 4	0,719	0,761	0,946	irs
MOC 5	0,810	0,810	1,000	-
MOE 1	1,000	1,000	1,000	-
MOE 2	1,000	1,000	1,000	-
MOE 3	1,000	1,000	1,000	-
MOE 4	0,950	1,000	0,950	drs
MOE 5	0,870	0,895	0,972	drs
MOE 6	0,934	1,000	0,934	drs
MOE 7	1,000	1,000	1,000	-
MD 1	0,893	1,000	0,893	irs
MD 2	0,811	0,826	0,982	irs
MD 3	0,830	1,000	0,830	irs
MD 4	0,861	0,998	0,863	irs
MD 5	0,571	0,619	0,922	drs
COOP 1	1,000	1,000	1,000	-
COOP 2	0,712	0,793	0,897	irs

The scale efficiency score is derived from the crste and vrste scores. So when e.g. MOE 4 has a crste value of 0,950, it means that it is reaching 95% of the efficiency that it should achieve, i.e. it should be able to reduce its use of inputs by 5% and still be able to produce the same amount of inputs. MOE 4 seems to get a vrste score of 1, so its inefficiency can be seen to result solely because of its wrong size (drs = too big). However, waterworks are not

necessarily the best targets for specific size determination, because they have their area of operation and they usually cannot change it radically in the short run. Consequently, this research concentrates mainly on crste and vrste efficiency values which are shown for reviewed waterworks in Figures 3 and 4.

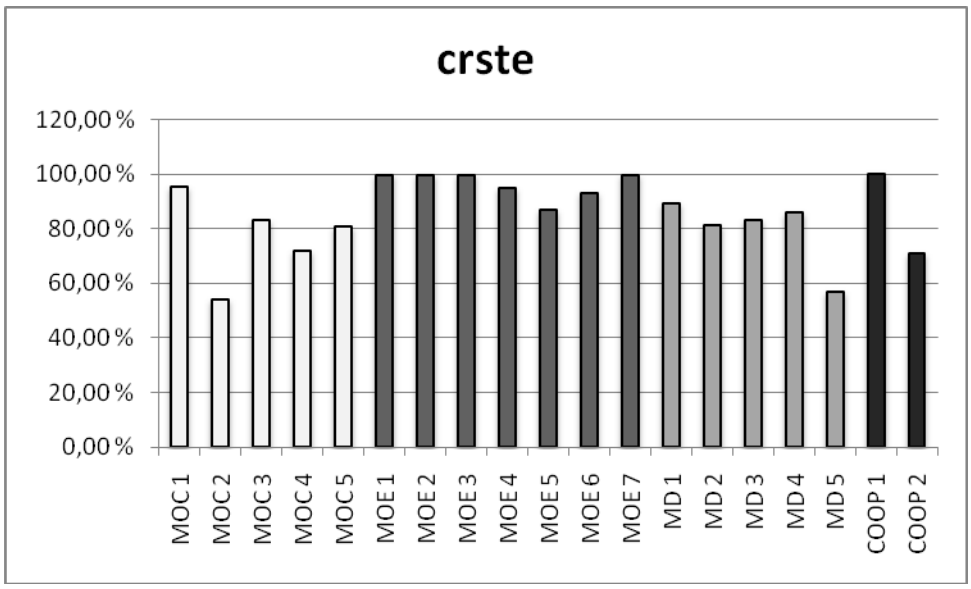

Figure 3: crst scores of reviewed waterworks.

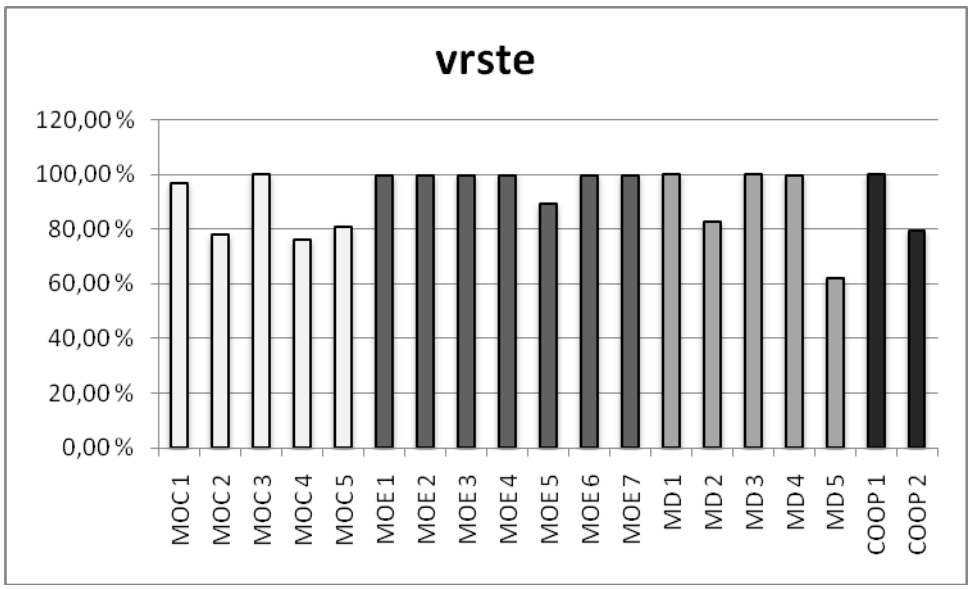

Figure 4: vrst scores of reviewed waterworks.

Research results seem to indicate, that municipal owned enterprises (MOE) are clearly best performers among the reviewed waterworks. The efficiency scores of MOEs are generally very good and it seems that MOE is the only governance model getting consistently good scores. Presupposition was that the municipal owned companies (MOC) would be generally efficient because of their greater freedom and independence compared to MOE and municipal department (MD), but the results showed poorer overall performance compared to MOEs. MD's showed systematically inferior scores compared to MOEs and MOCs although the municipalities may have their ways to make MD's look like more efficient than they really are by means of creative accounting.

Research results were tested for statistical significance with the Kruskal-Wallis and Mann-Whitney tests. The Kruskal-Wallis test showed that there exist statistically significant differences between some of the groups. Mann-Whitney tests revealed that the relation between MOEs and MDs is statistically significant, which means that MOEs are more efficient than MDs when measuring them with the DEA model. Despite these results, the MOCs seem to be doing worse than MOEs as well, which could have been verifiable with a larger sample size.

DISCUSSION

It was noticed during the research process, that there are numerous factors affecting the efficiency of waterworks which were not completely included in examination. Most of these exclusions were unwanted though, and caused by the lack of recorded information or homogeneity constraints of the group.

The literature and managerial interviews clearly pointed out that the comparisons of waterworks should take into account also quality and operation reliability factors. In order to achieve a balanced and applicable DEA model, these factors were however excluded since the number of variables was already at its maximum limit. This is a consequence of the small size of the comparison group of waterworks, which in turn is caused by homogeneity, representativeness, and applicability constraints. By excluding quality and reliability issues from the comparison, the reasons behind the different costs at different waterworks are not completely clear. Anyhow, inclusion of the quality and reliability issues in the same DEA model could have resulted in failure, because their cost correlation is not clear. Before there is evidence how to balance different quality factors in a way that their effect on total costs would be equal, it is hard to use them on similar grounds for cost related evaluation purposes.

The quantity, quality and availability of information are also somewhat hindering the implementation of accurate and plausible benchmarking studies. Despite the changes in law to improve transparency of waterworks there are still problems with its application. According to the research, it seems that in some cases all the costs are not recorded in waterworks departments' balance sheets, but instead in the balance sheets of municipality thereby blurring the real financial situation of the waterworks. In addition, there may be difficulties in defining the accurate cost allocation of billed and delivered water and billed and treated sewage since many waterworks sell water and/or sewage treatment services to other waterworks. Also in reality, for example rain waters increase (often more than double) the amount of sewage treated thereby causing costs that are not directly covered by sewage fees. A similar effect can be seen in the amount of billed water, which does not include the unaccounted-for-water which is lost and never gets to the customer.

CONCLUSIONS

The objective of this study was to find out if there are any differences in efficiency levels between waterworks' governance models. Data envelopment analysis (DEA) was selected as a research method since it has been widely used in previous waterworks benchmarking

studies and seemed to offer the best tool for assessing efficiency of different governance models. Previous literature has introduced dozens of different variables for DEA studies from which the most suitable ones were selected by taking into account the constraints of information availability and homogeneity of comparison group. Input variables used in this study were operating expenditure and capital expenditure and output variables volume of billed water, volume of billed sewage, number of water customers and number of sewage customers.

The results of this study indicate that there are differences in waterworks' governance models efficiencies. Statistically significant difference between the reviewed waterworks was found to exist among municipality owned enterprises and municipal departments, where municipality owned enterprises were generally more efficient ones. Municipality owned companies had very unequal efficiency results and the sample group of cooperatives was very small, why statistical difference could not be found regarding these groups. Furthermore, because the sample group included only 19 waterworks, these results cannot be generalized to the national level or too general level.

During the research it became clear that waterworks efficiency research has a lot of constraints to overcome of which availability of transparent and accurate information is the most prevailing one. Perhaps this has been contaminated by the heterogeneous public management policy. The efficiency scores from this DEA study are thus suggestive and they cannot be taken as an absolute truth because of many influencing factors in the background. This research was the first attempt to compare efficiency of waterworks' governance models in Finland. It gave interesting and somewhat promising results which should encourage researchers to investigate the matter further. This research should be used as a foundation for improved and perfected models in the future, since the findings seem to be logical. Future research could for example investigate how strongly each quality and reliability factor correlates with the total costs in order to ease the future efficiency evaluations and add also quality aspect into it. In addition, larger sample groups and more data should be collected in order to get more reliable and generalizable results.

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THE EFFECT OF INTERNAL CONTROLS ADAPTABILITY ON OPERATING PERFORMANCE

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ABSTRACT

The development and application of information technology makes it possible to automate the tasks of approving, recording, processing and reporting of transactions. To ensure operational performance, financial reporting reliability and legal compliance, internal control mechanisms should be gradually constructed into the information systems, according to the computerization of the enterprise, in order to continue to exercise the internal controls. Therefore, the main purpose of this study was to develop a model, in which internal controls adaptability affects internal controls efficacy and operating performance, and internal controls efficacy influences operating performance. Research hypotheses derived from the model were tested using regression analysis on the questionnaire data and financial data from Taiwanese listed companies. The results showed that not only internal controls adaptability had an impact on internal controls efficacy and operating performance, but also internal controls efficacy had a partial influence on operating performance. The research findings could be a theoretical foundation for further study.

Key words: information systems, computerized internal controls, internal controls adaptability, internal controls efficacy, operating performance

INTRODUCTION

The development and application of information technology (IT) makes it possible for companies to support operations with IT systems in order to improve operating performance. The approval, recording and processing of transactions, as well as the generation of reports can be automated, to ensure operational effectiveness and efficiency, financial information reliability, and legal compliance [4, 5, 13, 17, 25]. Companies have to adjust the techniques and methods of internal controls in accordance with computerization, in order to exercise effective controls. The internal control techniques used in an IT environment are quite different from those used in a manual environment. Transactions are automatically triggered or executed in an IT environment, and the internal controls are supported with information technology. Therefore, the internal control techniques in a manual environment cannot be migrated to an IT environment [19].

The formation of paperless trading environment means changes of the internal control techniques are required, so as to ensure consistency with the IT environment and the efficacy of internal controls. Therefore, the adaptations of internal control techniques are a

critical management issue in order to ensure the efficacy of internal controls and the achievement of operational objectives.

In the IT environment, the quality of internal controls adaptation affects operations and management, and in turn, influences the efficacy of internal controls [29]. Internal controls aim to ensure the reliability of financial information, the effectiveness and efficiency of operations and the compliance of laws and regulations [41]. Therefore, the efficacy of internal controls can be divided into the reliability of financial information, the effectiveness and efficiency of operations and the compliance with laws and regulations. The efficacy of the control over financial information reliability allows managers to gain a timely and in-depth understanding of business operations. This empowers them to make the right decisions and improve operational performance [7, 21, 40, 41]. The effectiveness and efficiency of operations ensures the outcomes of resources utilization reduce unnecessary waste in operational activities and eventually boost operating performance [18,29]. The control efficacy of the compliance with laws and regulations can prevent illegal or fraudulent behavior and ensure operating performance [1, 21, 39].

The robustness of an internal control system affects the efficacy of internal controls. Meanwhile, the efficacy of internal controls influences operational performance via information reliability, operational effectiveness and efficiency, and legal compliance [7, 21, 41]. In the IT environment, adaptations on computerized internal controls have effects on the efficacy of internal controls and the performance of operations. In fact, the efficacy of internal controls also affects operating performance.

Literature suggests that the importance of computerized controls on operations [18, 19, 21, 41]. However, there are no discussions regarding how the adaptability of computerized controls affects operational performance through the efficacy of internal controls. Therefore, this paper reviewed literature and examined how the adaptability of computerized controls affects operational performance through the efficacy of internal controls. Meanwhile, this paper referred to operational metrics such as ROA (return on assets), ROE (return on equity) and EPS (earnings per share) as dependent variables to perform an empirical study on how the adaptability of computerized controls affects operating performance and the efficacy of internal controls, and how the efficacy of internal controls affects operating performance.

RESEARCH MODEL AND HYPOTHESES DEVELOPMENT

Internal controls

Internal controls, implemented by the board of directors, management and others, aim to provide a reasonable assurance of the reliability of financial reporting, the compliance with laws and regulations and the effectiveness and efficiency of operating [4, 5, 13, 17, 25]. The quality of the design of internal controls, more often than not, is critical to the success of an organization. Therefore, to ensure the efficacy of internal controls, managers have to pay attention to the design of internal controls.

The internal control- integrated framework proposed by COSO (Committee of Sponsoring Organizations of the Treadway Commission) consists of five control components, i.e. the

control environment, risk assessments, control activities, information and communication, and monitoring. The control environment is the foundation of the other four components [17]. Risk assessments refer to the process of identifying and evaluating risks. Control activities are a set of policies and procedures to assist and ensure the implementation of the instructions from management. The setup and execution of these policies and procedures should target identified risks. Information is defined as the objects the IT system identifies, measures, processes and reports. Information can be generated internally or acquired externally. Information aims to assist decision-makers in reaching decisions. Communication is the process of delivering information to others. Monitoring is the process of evaluating internal control implementations, in order to decide whether control activities are still relevant, whether risks can still be identified and whether the design and implementation of control activities remain effective.

Companies have to implement various control measures to achieve targets. On the basis of the timing of control events, internal controls can be divided into preventive controls, detective controls and corrective controls [17]. Preventive controls are ex-ante in nature, such as the control over accounts and passwords for the prevention of illegal uses from logging into the system. Detective controls are the control over the happening of events, e.g. the inspection of product codes to confirm the existence of products. Corrective controls are ex-post nature. For example, an automated procurement system can calculate the procured quantity once the inventory falls below a control point, and then generate a purchase order to make up for the inventory shortfall.

The execution of internal controls can be divided into manual controls and computerized controls [12]. Manual controls refer to the control mechanisms implemented by users, e.g. manual reviews of the results processed by the computer. Computerized controls refer to the automated control run by computer programs, such as a check on whether debts and credits are balanced in the accounting entries made by users.

According to No. 3 of the Statements of Auditing Standards (SAS) set forth by the American Institute of Certified Public Accountants (AICPA), the structure of internal controls in the EDP environment can be divided into general controls and application controls [24] General controls can be further divided into organization and operation controls, systems development and documentation controls, built-in equipment controls, access controls and other data and procedural controls. Application controls can also be further divided into input controls, processing controls and output controls. In other words, general controls are about the control of the whole IT environment, with the goal of ensuing the security and reliability of the IT system. Application controls are about the control over application software, aiming to maintain the accuracy and integrity of data from inputs when processed to outputs. Regardless of how perfect the design of an internal controls system, it is difficult to completely work out the functions of internal controls, due to practical limitations and the cost/benefit tradeoff, as well as the continued likelihood of illegal activities [27,31].

The assessment of enterprise computerization

The digitalization, mobilization and ubiquity of information technology extend the virtual boundaries of organizations. As a result of the integration of workflows both inside and

outside the organization, electronic transaction data has replaced paper-based data [22, 32]. The extension of virtual boundaries of organizations and the digitalization of internal and external transaction data lead to organizational transformations and changes in corporate structures, flows and behavior [10, 11, 12, 17, 30, 34, 38]. The adoption of new information technology extends the reach of IT systems and changes the integrated processing capacity of transaction data. As a result, corporate structures, work flows and behavior also shift. The computerization process to extend the reach of the IT system and the capability to integrate and process transaction data is, in essence, the transformation process of corporate structures, work flows and behavior. Therefore, the enterprise computerization can be explained using the extensibility of information systems and integrated processing capability of transaction data as two indicators [22, 26, 32].

IT systems may consist of platforms such as a single computer, LANs(local area networks) and the Internet. LAN-based IT systems have a stronger extension capability than single-computer-based systems, and Internet-based systems are even stronger than LAN-based systems in terms of extension capacity. As far as the transaction integration is concerned, Manufacturing Resources Planning Systems are better than Material Requirement Planning Systems, and Enterprise Resources Planning Systems are superior to Manufacturing Resources Planning Systems.

The adaptation of computerized internal controls

The adoption of new information technology means computerized controls should be built into the IT system. The higher the degree of computerization, the more likely transactions will be generated or implemented automatically. Hence, computerized controls will gradually replace manual controls, in order to establish an automated and timely control mechanism. Jackson (2000) indicated that despite constant advances of information technology, many internal auditors stick to the traditional approach of control applications and IT system controls. This is how many internal control defects emerge. Tuttle (2007) suggested that the responsibility of computer auditors is to ensure that the control and security of the IT system is taken into consideration during its planning and development. Given the development and application of information technology, it is necessary to switch internal controls from the traditional manual approach to an automated and programmed approach in order to ensure security and reliability of the IT system [29].

Bierstaker et al. (2001) indicated that changes of the IT environment affect internal control techniques and audit methods. Therefore, adaptation is required between computerization and internal control techniques. Weber (1982), and Davis and Weber (1986) proposed an adaptation model for internal control and audits based on the theory of a computerized data processing system. This system consists of nine levels, i.e. environment, organization, user divisions/departments, the data processing facility, data processing systems, computer data processing subsystems, components, controls and audit procedures. Adjustments are made to the environment or technology of the lower level in response to dynamic pressure from the upper level, in order to identify the control and audit techniques required. Therefore, the IT environment affects IT system changes, the IT system influences changes of the internal control techniques, and the internal control techniques drive changes of the audit procedures and methods.

The development and application of information technology changes the extensibility of information systems that support an organization and the integrated processing capability of transaction data. The extensibility of information systems that support an organization refers to the level of openness of the extensibility of information systems networks. In other words, it is an indicator of whether transaction data can be entered in a timely manner. An open information system allows operators to immediately input transaction data no matter where the transactions take place. To ensure the security and reliability of operations, it is necessary for the internal control mechanism to acquire transaction data on a timely basis. A timely internal control mechanism should be deployed to ensure the efficacy of internal controls. The integrated processing capability of transaction data refers to the capability to integrate and process the data of related transactions via networks and databases. In such a paperless IT environment, managers should establish a programmed and automated internal control mechanism to implement automated control and ensure internal controls efficacy.

The maturity of IT applications and the development of network technologies mean there are no restrictions of time or space on the extensibility of the information systems. No matter where the transactions occur, operators can immediately enter transaction data into an information system over open network. The maturity of network and database technologies makes it possible to integrate and process transaction data across divisions over networks and databases. In a paperless and digital trading environment, internal control techniques must be timely and automated to ensure control efficacy and achieve operational goals [8, 14]. Therefore, this paper referred to internal controls automation and internal controls timeliness as the two indicators to explain internal controls computerization.

According to Figure 1, enterprise computerization consists of the integrated processing capability of transaction data and the extensibility of information systems. The internal controls computerization consists of the internal controls automation and the internal controls timeliness. Any increase of computerization means the adaptations of automation and timeliness of internal controls become necessary on the basis of the integrated processing capability of transaction data and the extensibility of information systems. The establishment of computerized internal controls is essential to ensure the efficacy of internal controls. Throughout the computerization process, certain corporate characteristics make it impossible to adapt internal control techniques accordingly, and hence, internal control deficiencies occur. The quality of the adaptation towards computerized internal controls influences the efficacy of internal controls and the performance of corporate operations.

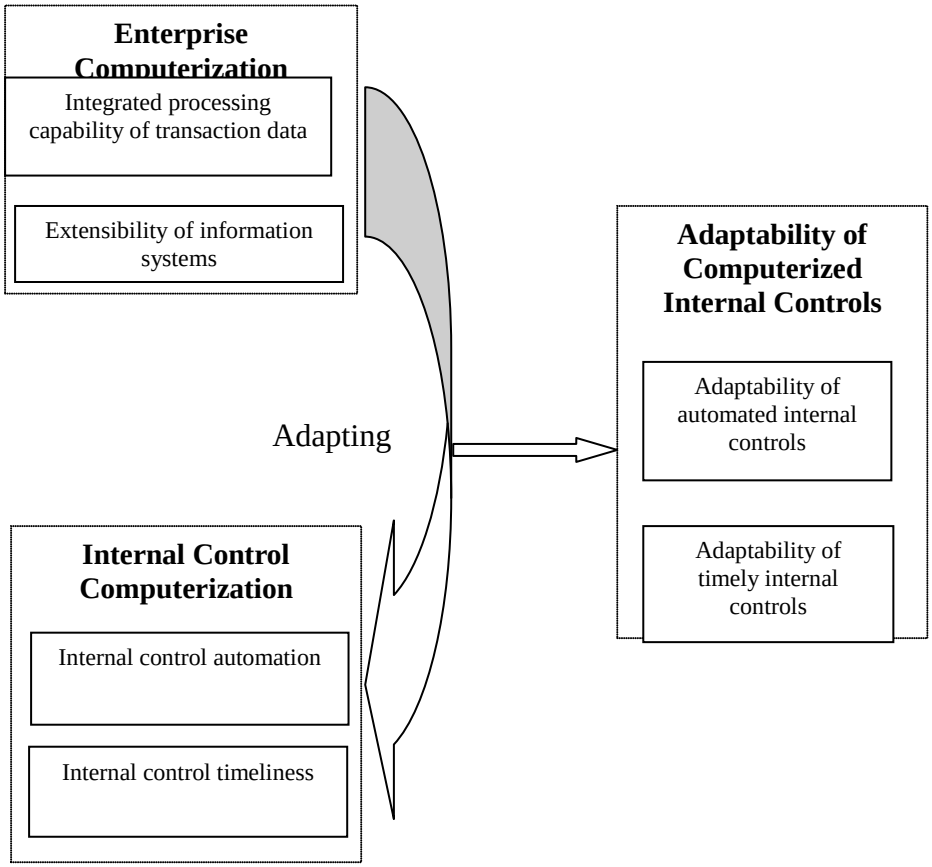

Figure 1: Computerized internal control adaptation.

Hypotheses development

Companies are utilizing IT and network technologies to integrate functions across the value chain so as to best allocate limited resources, to exercise effective control, and to achieve operational goals. Hardy and Reeve (2000) indicated that a reliable internal control structure aims to ensure information accuracy in the integration process of the EDI (electronic data interchange) system. Davis and Weber (1986) argued that the application of control procedures and methods at the right time and in the right environment can achieve good cost efficiency. Doty et al. (1989) suggested that internal control methods should be in line with the structure of the databases from the perspective of database designs, in order to adjust internal control formats, ensure internal control efficacy and boost operational performance. Harper (1986) examined the level of computerization in the context of network developments. Networks and optical infrastructure speed up transmissions and data exchanges between computers. As a result, management is more able to exercise timely controls and achieve business objectives. Therefore, internal control techniques should change in accordance with the IT environment. The adaptability of computerized internal controls affect internal controls efficacy, and hence, operating performance.

Performance evaluations and control management are highly related. Operating performance plays a pivotal role in control management and affects the operations of the whole organization. Incentives and rewards to employees, as well as operational targets and

overall goals, are all based on the evaluation of operating performance [33]. There is extensive literature addressing operating performance, and most of it centers on the three financial metrics of ROE, ROA and ROS, as proposed by Venkatraman and Ramanujam (1986). This paper also referred to ROE and ROA but added EPS as another indicator to evaluate performance. These three dependent variables, ROE, ROA and EPS, were used to examine the influence of internal control efficacy on operating performance.

As Figure 2 illustrates, the adaptability of computerized internal controls affects internal control efficacy and operating performance. Internal control efficacy can be divided into the control efficacy of financial information reliability, the control efficacy of operating effectiveness and efficiency and the control efficacy of laws and regulations compliance. The efficacy of internal controls, in turn, affects operating performance.

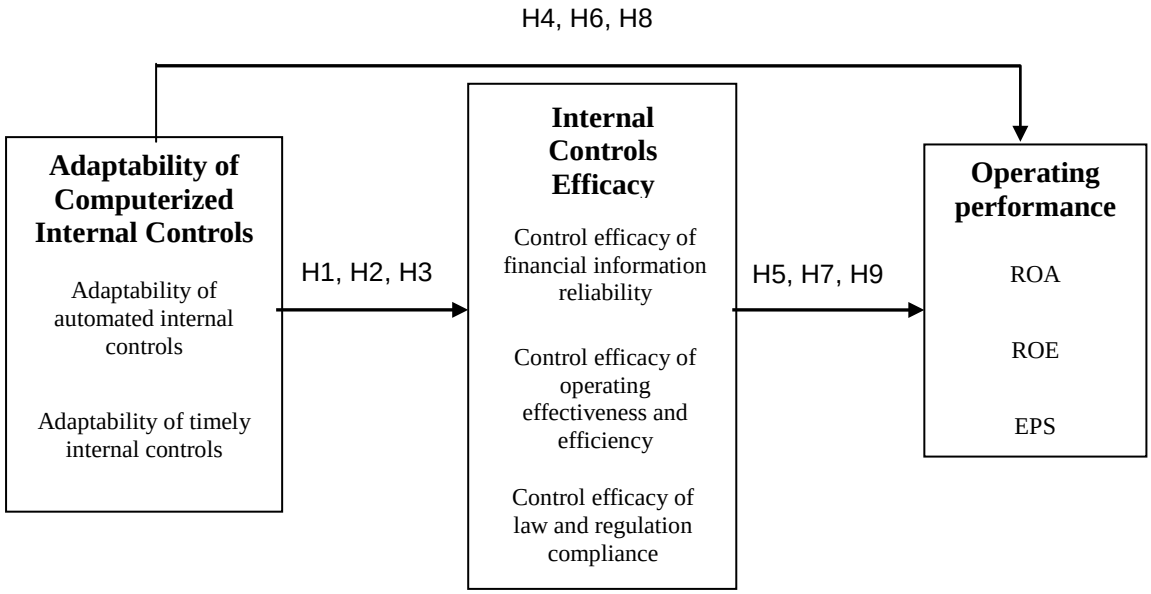

Figure 2: the proposed research model.

The completion of the IT systems required for transactions allows users to experience the efficiency and convenience brought about by the IT system. Users will request to integrate more functions into the IT systems in order to integrate and process transaction activities. After the replacement of the manual environment with the IT systems, it is necessary to deploy more computerized controls in order to avoid any control loopholes [19]. If companies are able to adjust their computerized control mechanism according to the degree of IT applications, they will be able to ensure the reliability of financial information processing and boost the control efficacy of the financial information reliability [21]. Hence, this study developed the following hypothesis:

H1: The higher the adaptability of computerized internal controls, the better the control efficacy of financial information reliability.

With the deployment of the required internal control mechanisms into the IT system, the IT system can effectively and efficiently support transaction activities as well as ensure operational effectiveness and efficiency, information quality and legal compliance. This leads to the improvement of the control efficacy of operational effectiveness [6, 21]. Hence, this

study developed the following hypothesis:

H2: The higher the adaptability of computerized internal controls, the better the control efficacy of operating effectiveness and efficiency.

Good adaptability of computerized internal controls and the deployment of the automated and timely internal control mechanisms in the IT system can prevent and detect in a timely-manner any erroneous or illegal transactions. This improves the control efficacy of legal compliance [21]. Thus, this study developed the following hypothesis:

H3: The higher the adaptability of computerized internal controls, the better the control efficacy of laws and regulations compliance.

Internal controls are run to ensure the achievement of operational goals and performance [9]. The more enterprise computerization and internal controls are aligned, the more reliable the financial information, the smoother the operations and the better the legal compliance. This leads to internal control efficacy and operational performance improvements [41].

Return on assets (ROA) is an indicator of operating performance because it represents the efficacy and efficiency of asset utilization. There is a certain correlation between the adaptability of computerized internal controls, the efficacy of internal control and operating performance. Internal control efficacy also has a positive influence on operating performance [7,41]. Therefore, this study developed the following hypotheses:

H4: The higher the adaptability of computerized internal controls, the higher the ROA.

H5: The better the internal control efficacy, the higher the ROA.

Return on equity (ROE) is the speed of growth of shareholders' equity. It measures whether management's goals and the shareholders' goals are aligned. ROE is a valuation metric of operating performance. The adaptability of computerized internal controls and the efficacy of internal control affect operating performance [21]. Thus, this study developed the following hypotheses:

H6: The higher the adaptability of computerized internal controls, the higher the ROE.

H7: The better the internal control efficacy, the higher the ROE.

Earnings per share (EPS) are the profitability of a company. The higher the EPS, the better the profitability per unit of capital is. A high EPS is the result of good marketing, technologies and management, which makes it possible to create better bottom lines with fewer resources. EPS is an important performance indicator.

The adaptability of computerized internal controls saves transaction costs and improves operational efficiency via operations and efficiency control efficacy. It also reduces cases of fraud and mistakes via the efficacy of control over legal compliance, and in turn, influences operating performance [1, 6]. Hence, this study developed the following hypotheses:

H8: The higher the adaptability of computerized internal controls, the higher the EPS.

H9: The better the internal control efficacy, the higher the EPS.

RESEARCH METHODS

Variables definitions

In order to operate and measure the variables, table 1 defines the related variables of this study.

Table 1: definitions of variables.

Constructs	Variables	Definitions	References
Enterprise Computerization	Integrated processing capability of transaction data	Capability of integrating and processing transaction data in the IT systems.	Hong and Kar (2006), Krishnan et al. (2005), Serenko et al. (2008)
	Extensibility of information systems	Capability of the IT system in extending the reach of virtual boundaries of transaction activities for an organization	
Internal Control Computerization	Internal control automation	Capability of deploying automated internal controls in the IT system	Ashbaugh-skaife et al. (2007, 2009), Bailey (1985), Grant et al. (2008), Hardy and Reeve (2000)
	Internal control timeliness	Capability of deploying timely internal controls in the IT system	
Adaptability of Computerized Internal Controls	Adaptability of automated internal controls	Adaptability between integrated processing capability of transaction data and internal controls automation.	Weber (1982), Davis and Weber (1986)
	Adaptability of timely internal controls	Adaptability between extensibility of information systems and Internal controls timeliness.	
Internal Control Efficacy	Control efficacy of financial information reliability	Internal control efficacy to ensure financial information reliability.	Barra (2010), Boone et al. (2000)
	Control efficacy of operating efficacy and efficiency	Internal control efficacy to ensure compliance with laws and regulations.	
	Control efficacy of law and regulation compliance	Internal control efficacy to ensure operational effectiveness and efficiency	
Operating performance	Return on assets (ROA)	Net income divided by average total assets	Venkatraman and Ramanujam (1986), Snell (1992)
	Return on equity (ROE)	After-tax profits divided by weighted average shareholders' equity	
	Earnings per share (EPS)	Net income divided by the number of weighted average common shares outstanding	

The adaptability of computerized internal controls refers to the capability of deploying computerized internal controls according to the levels of computerization. Enterprise computerization is defined as the integrated processing capability of transaction data plus the extensibility of information systems. The internal control computerization is defined as the internal controls automation plus the internal controls timeliness. Therefore, the adaptability of internal controls automation is defined as the internal controls automation divided by the integrated processing capability of transaction data. The adaptability of internal controls timeliness is defined as the internal controls timeliness divided by the extensibility of information systems. The adaptability of computerized internal controls is defined as the internal controls computerization divided by the enterprise computerization. The value of the adaptability of computerized internal control is between 0 and 1. A value of 0 means a complete lack of adaptability. A value of 1 indicates the best adaptability. To ensure the validity of the questionnaire data, the samples with adaptability values of greater than 1 were deleted.

Measurement

The questionnaire survey consisted of four parts. Part 1 detailed the basic data of the sampled companies, and there were five items. Part 2 contained items about enterprise computerization. Part 3 contained a set of items on the computerization of internal controls. Part 4 contained items on internal control efficacy. There were ten items in Part 2 and these items were designed for IT personnel. The purpose was to acquire the assessment values of enterprise computerization. There were ten items in Part 3 and nine items in Part 4. These items were designed for auditing staff, in order to acquire the assessment values of the capability of computerizing internal controls and the efficacy of internal controls. The items in Parts 2, 3 and 4 were all based on the Likert Scale. All items were positive statements. There are five answers to each question, stated as: “strongly agree” (5 points), “agree” (4 points), “uncertain” (3 points), “disagree” (2 points) and “strongly disagree” (1 point). Among the ten items in Part 2, items 1 to 5 aimed to evaluate the integrated processing capability of transaction data. Items 6 to 10 intended to assess the capability of extending the IT system. Among the ten items in Part 3, items 1 to 5 sought to measure the capability of automating internal controls, whereas question 6 to 10 intended to gauge the timeliness of internal controls. Among the nine items in Part 4, items 1 to 3 aimed to assess the efficacy of control over financial information reliability, items 4 to 6 intended to measure the efficacy of control over the compliance of laws and regulations, and items 7 to 9 sought to evaluate the control efficacy of operational effectiveness and efficiency.

To ensure the content validity of the questionnaires, this paper developed the items by referring to relevant literature and the research model. The questionnaire was finalized with minor changes after a pre-test on the IT and auditing personnel of a large global corporation and other three companies.

Data collection

Listed companies tend to be large in scale, and are usually generous in IT investments. As heavy users of information technology, they have higher levels of computerization. This paper hence decided to randomly sample listed companies in Taiwan across different

industries. A total of 601 companies were selected. The questionnaires were released to the CEOs of sampled companies by post or email in mid December 2010. The CEOs were requested to forward the questionnaires to relevant IT and audit personnel. The purpose of this survey was to gather construct data concerning the capability of computerization, the capability of computerizing internal controls and the efficacy of internal controls. Quantitative metrics, such as ROA, ROE and EPS, were sourced from the Taiwan Economic Journal. This paper referred to the mean values of the three most recent years (2007~2009).

ANALYSIS AND RESULT

There were 67 valid questionnaires returned, showing a response rate of 11%, which could still be accepted. Table 2 shows the descriptive statistics such as means and standard deviations of variables.

Table 2: Descriptive statistics of variables.

Variables	Mean	Standard deviation	Theoretical score range	Real score range
Integrated processing capability of transaction data(IPCOTD)	20.27	2.434	5-25	15-25
Extensibility of information systems(EOIS)	20.27	2.700	5-25	15-25
Internal controls automation(ICA)	18.01	2.555	5-25	13-23
Internal controls timeliness(ICT)	18.01	2.371	5-25	13-23
Controls efficacy of financial information reliability(CEOFIR)	11.45	1.247	3-15	9-14
Controls efficacy of operating effectiveness and efficiency(CEOEAE)	11.58	1.170	3-15	9-14
Controls efficacy of law and regulation compliance(CEOLAR)	11.51	1.284	3-15	8-14
Adaptability of internal controls automation(AOICA)	0.892	N/A	N/A	N/A
Adaptability of internal controls timeliness(AOICT)	0.890	N/A	N/A	N/A

According to Table 2, the mean values of IPCOTD and EOIS as two variables were both 20.27, and were close to the highest value of 25. In general, listed companies in Taiwan have high levels of computerization. The adaptability values, AOICA and AOICT, were 0.892 and 0.890, respectively. These numbers suggested a strong adaptability of computerized internal controls. In other words, most listed companies in Taiwan can adjust their internal controls in accordance with their levels of computerization.

Table 3 summarizes the descriptive statistics of ROA, ROE and EPS of the sampled companies for 2007, 2008 and 2009.

Table 3: descriptive statistics of performance indicators.

Performance indicators	Mean	Standard deviation	Maximum	Minimum
ROA	1.58%	0.97%	3.50%	-1.10%
ROE	2.17%	1.22%	4.70%	-1.70%
EPS	1.75	1.09	4.37	-1.73

Reliability and validity

In order to evaluate the consistency of the construct factors, such as computerization capability, the capability of computerizing internal controls and the efficacy of internal controls, this paper referred to Cronbach α values to validate reliability. The Cronbach α values for integrated processing capability of transaction data, extensibility of information systems, internal controls automation, internal controls timeliness, control efficacy of financial information reliability, control efficacy of operating effectiveness and efficiency, and control efficacy of laws and regulations compliance were 0.869, 0.821, 841, 0.826, 0.709, 0.603 and 0.614, respectively. Five of them met the threshold of 0.7, as suggested by Munnally (1990). The other two 0.603 and 0.614 could also be accepted. These values demonstrated the reliability of the constructs was high.

Regarding the measurement of construct validity, this paper referred to seven indicators, i.e. the integrated processing capability of transaction data (IPCOTD), the Extensibility of information systems (EOIS), the Internal controls automation (ICA), the internal controls timeliness (ICT), the control efficacy of financial information reliability (CEOFIR), control efficacy of operational effectiveness and efficiency (CEOOEAE) and the control efficacy of laws and regulations compliance (CEOLARC) for the confirmatory factor analysis. The results are shown in Table 4. The coefficient of each construct was larger than the coefficients with other constructs. In every domain, the factor loadings of items for each construct were greater than 0.5, and the factor loadings for other constructs were less than 0.5. This suggested that convergent validity and discriminant validity were good and that further analysis was possible [28].

Table 4: confirmatory factor analysis.

Domain	Constructs	Items	Factor loadings	Eigenvalue	Cronbach's Alpha
Enterprise computerization	Integrated processing capability of transactions data(IPCOTD)	IPCOTD1	0.817	3.372	0.869
		IPCOTD2	0.747		
		IPCOTD3	0.742		
		IPCOTD4	0.673		
		IPCOTD5	0.711		
	Extensibility of information systems(EOIS)	EOIS1	0.653	3.097	0.821
		EOIS2	0.792		
		EOIS3	0.556		
		EOIS4	0.635		
		EOIS5	0.561		
Internal controls computerization	Internal controls automation(ICA)	ICA1	0.773	2.935	0.841
		ICA2	0.639		
		ICA3	0.527		
		ICA4	0.621		
		ICA5	0.729		
	Internal controls timeliness(ICT)	ICT1	0.673	3.023	0.826
		ICT2	0.594		
		ICT	0.729		
		ICT4	0.626		
		ICT5	0.677		
Internal controls efficacy	Control efficacy of financial information reliability(CEOFIR)	CEOFIR1	0.525	1.870	0.709
		CEOFIR2	0.578		
		CEOFIR3	0.622		
	Control efficacy of operating effectiveness and efficiency(CEOOEAE)	CEOOEAE1	0.667	1.961	0.603
		CEOOEAE2	0.633		
		CEOOEAE3	0.576		
	Control efficacy of laws and regulation compliance(CEOLARC)	CEOLARC1	0.674	2.174	0.614
		CEOLARC2	0.751		
		CEOLARC3	0.770		

Regression models

The proposed hypotheses were tested using regression analyses. The results are summarized in Table 5. The F values of the nine regression models all reached the significance level of 0.001, and the coefficients of the independent variables were all greater than 0. This suggested that there was a significant correlation between the independent variables and dependent variables. The modified coefficients were Adj R^2=0.685, Adj R^2=0.695, Adj R^2=0.700, Adj R^2=0.762, Adj R^2=0.735, Adj R^2=0.757, Adj R^2=0.695, Adj R^2=0.722, and Adj R^2=0.685. Therefore, the independent variables could explain 68.5%, 69.5%, 70.0%, 76.2%, 73.5%, 75.7%, 69.5%, 72.2% and 68.5% of the variances of dependent variables, respectively.

Table 5: Results of regression analyses.

Hypotheses	Adjusted R^2	F values	Regression equations	Hypotheses testing
H1	0.685	72.693***	CEOFIR = -1.517 + 7.120(AOICA***) + 7.435(AOICT**)	Supported
H2	0.695	76.060***	CEOOEAE = -0.574 + 7.228(AOICA***) + 6.418(AOICT**)	Supported
H3	0.700	78.095***	CEOLARC = -2.090 + 6.782(AOICA***) + 8.484(AOICT***)	Supported
H4	0.762	106.465***	ROA = -0.092 + 0.049(AOICA***) + 0.072(AOICT***)	Supported
H5	0.735	62.115***	ROA = -0.067 + 0.001(CEOFIR) + 0.003(CEOOEAE*) + 0.003(CEOLARC***)	Partially Supported
H6	0.757	103.813***	ROE = -0.114 + 0.050((AOICA**) + 0.103(AOICT, t=5.197***)	Supported
H7	0.695	51.136***	ROE = -0.067 + 0.001(CEOFIR) + 0.003(CEOOEAE*) + 0.003(CEOLARC***)	Partially Supported
H8	0.722	86.722***	EPS = -10.235 + 3.910((AOICA*) + 9.544(AOICT***)	Supported
H9	0.685	48.891***	EPS = -0.067 + 0.001(CEOFIR) + 0.003(CEOOEAE) + 0.003(CEOLARC***)	Partially Supported

Other than H5, H7 and H9, the remaining six regression models had positive coefficients and significant t values. The t values for CEOFIR, an independent variable, of H5 and H7 did not reach significance levels, meaning the control efficacy of financial information reliability did not have a significant influence on ROA and ROE as dependent variables. In the H9 regression model, the t values for CEOFIR and CEOOEAE as independent variables did not reach statistical significance, meaning the control efficacy of financial information reliability and the control efficacy of operational effectiveness and efficiency did not have a significant influence on EPS as a dependent variable. As Table 5 shows, H1, H2, H3, H4, H6 and H8 were supported and H5, H7 and H9 were partially supported.

FINDINGS AND DISCUSSION

The adaptability of computerized internal controls affects the efficacy of internal controls, and the efficacy in turn affects operating performance. The internal control mechanism, however, will lead to operating performance only through the process of internal control efficacy. The comparison of the H1, H2 and H3 results and the H5, H7 and H9 results showed that the explanatory power of the capability of computerized internal controls on variances of operating performance indicators (i.e. ROA, ROE and EPS) was stronger than that of internal control efficacy. In other words, the capability of computerized internal controls could better predict operating performance than internal control efficacy. The capability of computerized internal controls was therefore shown to be an effective predictor of operating performance.

The H5, H7 and H9 results also showed the different levels of influence of the three independent variables, i.e. the control efficacy of financial information reliability, the control efficacy of operational effectiveness and efficiency and the control efficacy of laws and regulations compliance on the dependent variables, i.e. operating performance indicators of ROA, ROE and EPS. The control efficacy of financial information reliability had no significant

influence on these three performance indicators, i.e. ROA, ROE and EPS. Operational effectiveness and efficiency control efficacy had a significant influence on ROA and ROE, but not on EPS. Control efficacy on legal compliance had a significant influence on ROA, ROE and EPS. Control efficacy of financial information reliability may be relevant to external users of financial information but not directly related to internal operations. Hence, it did not have a direct impact on operating performance. Legal compliance may boost operating performance by reducing errors and fraudulent behavior, so it had direct effects on operating performance.

The major contribution of this paper was to examine the importance of the adaptation of computerized internal controls in a digital environment, and to perform an empirical analysis on the influence of such adaptation on internal control efficacy and operating performance. The deployment of automatic and timely computerized internal controls in an IT system, in accordance with the levels of computerization, means good adaptation capability in computerized internal controls. This will influence internal control efficacy and operational results. The results can serve as a foundation for further studies, as well as a reference in the deployment of internal controls for the adoption of a new IT system.

This paper endeavored to be robust in its approaches, but it had two research limitations due to environmental factors such as time, manpower and resources.

- The empirical research was based on a questionnaire survey. It gauged the perceptions of respondents but could not ensure whether the respondents truly understood the items and provided factual answers.
- The research scope was limited to listed companies in Taiwan pursuant to the Taiwan Securities and Exchange Commission.

CONCLUSION

Based on literature reviews and empirical studies, this paper proposed an adaption model for the computerization of internal controls, as a reference for the establishment of internal controls in an IT system along with the evolution of the IT environment. The adaptation capability of computerized internal controls and the efficacy of internal controls were defined as the dependent variables of internal control efficacy and operating performance in the regression analysis. The results showed that the adaptation capability of computerized internal controls had a significant influence on internal control efficacy and operating performance. However, the influence of internal control efficacy on operating performance indicators such as ROA, ROE and EPS was significant only in the case of certain independent variables.

The formation of paperless transactions means computerized controls should make adjustments accordingly, in order to ensure the consistency between internal control techniques and the IT environment. This will ensure the efficacy of internal controls and the achievement of organizational objectives.

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SELECTING KEY PERFORMANCE INDICATORS IN CONSUMER DRIVEN ENTERPRISES: STUDY IN HEAVY-DUTY VEHICLE INDUSTRY

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ABSTRACT

This research investigates how the most effective key performance indicators (KPIs) can be selected for a customer-oriented company in the heavy-duty vehicle (HDV) industry. It is emphasized that there is a need for identification and utilization of KPIs based on the most important critical success factors (CSFs) of a customer-driven enterprise in order to create value, responsiveness, innovativeness, and differentiation. The stepwise procedure is applied to identify the most important KPIs. Firstly, sample mission statements and vision statements were analyzed. In the second step, CSFs of a consumer-oriented enterprise in the HDV industry were specified. In the third step, a characteristics table with regard to CSF was designed in the context of requirements, benefits, risk and limitation. In the fourth step, the KPI pool with 42 KPIs was generated. In the last step of stepwise procedure, KPI value table was established with the help of analyzed CSFs and the selected departments, which are thought as a link between company and its customers. Moreover, as a result, there are selected 17 KPIs. They are analyzed in the context of competitiveness, consumer-driven point of view, and accuracy in operations. This research shows that there is a strong correlation between mission statements and vision statements, strategic goals, CSFs and KPIs. Also, all of these components should focus on the same idea to be able to develop a consumer-driven structure.

Keywords: Consumer Driven, Key Performance Indicators, Critical Success Factors, Heavy Duty Vehicle industry, Competitiveness

INTRODUCTION

The globalization in the heavy-duty vehicle (HDV) industry is evident. Vehicle producers have spread their supply operations around the world and are selling products worldwide. In recent years, the vehicle market has increased drastically in e.g. India, Brazil and China, which are dominant part of the newly industrialized countries (NIC) with a rapid growth and fairly low labor costs. Less constraints and agility in just-in-time supply services make this industry larger in the globalization and more favorable (Frost and Sullivan, 2006). In the global HDV market, customer and market data and information are important for every company in order to understand the market and its potential. The holistic understanding and benchmarking succeed the firm to achieve appropriate levels in different aspects such as customer satisfaction (Hanman, 1997; Ittner et. al., 2003).

The HDV industry focuses on operational efficiency thus a firm focusing on the consumers may become an innovator in this industry. This means that a consumer-oriented approach may offer opportunity for differentiation and creation of competitive advantage. Also, if the company focuses on demand chain management, it will turn into a pioneer in the industry (Walters et. al., 2004). Firms in this industry are facing many challenges with regard to environmental issues, market share, image, cost structure, and fuel efficiency. Competitiveness in volume, price, lead-time and quality can be achieved through increase in product customization requiring improve market mediation in the exciting structure (De Treville et.al. 2004). In addition, the trend of globalization causes hard competition, which leads to increased product variety and differentiation resulting in reduced product lifecycles. These difficulties explain the recent interest of changing the mindset from supply chain management (SCM) to demand chain management (DCM). The importance of being consumer oriented is the starting point for the shift from SCM to DCM and it implies that companies should aim to improve responsiveness in meeting specific consumer needs. This change is obviously bringing complexity and cost into the supply chain.

This research investigates how the most effective key performance indicators (KPIs) can be selected for a customer-oriented company in the HDV industry. Using the result of KPIs can promote a standard method of performance measurement and find potentials for improvements in DCM area (McKinnon, 2007). The study emphasizes that there is a need for identification and utilization of KPIs based on the most important critical success factors (CSFs) to create value, responsiveness, innovativeness, and differentiation in consumer-driven enterprises. There exists research about CSFs for various types of tasks and industries as well as on the issue of identifying and implementing KPIs. However, research has not targeted specific industries such as the HDV industry. Thus, there is a lack of knowledge about the development of effective KPIs from an industry-based point of view. There is also a lack of studies relating consumer-oriented CSFs with effective KPIs. The aim of this study is to provide a framework that helps to identify the most appropriate consumer oriented KPIs in HDV industry. The main research question is: “How can the most effective KPIs be selected for a customer-oriented company in the HDV industry”. In essence, this research addresses how measurable KPIs in the operational level can be selected to reinforce the enterprise to be more consumer-driven.

Before continuing the context of the study should be explained. In this research customer and consumer concepts is separated from each other. In general, the customer is a potential buyer but not necessarily the final user of the product and the consumer is a value receiver in form of the final user. This is also the case in the HDV industry where there are two types of commodity owners. The first category is private importers who buy the products to sell in the market (considered as a customer) and the second category is exact value receivers, who buy the product via dealerships (considered as a consumer). Being aware of the difference between consumer and customer concepts, a short chain is considered for heavy-duty truck automotive industry including supplier, manufacturer, and end-user.

LITERATURE REVIEW

According to Christopher et. al.(2003), increasing trend of globalization causes tough competition in the market. As parallel with competition, product variety and attention for customer-adapted products increase while product life cycle decreases. Companies come across new challenges and they need to be more flexible while reacting to changes in market. Customers have great impact on today's business market. The alteration in customer demand brings complexity and extra costs to the supply chain. This means that firms need to increase their investments for satisfying the needs of customers, create value for the customers and gain competitive advantage in the market (IBM Corporation, 2004).

The need for customer-oriented structures may be considered as a starting point for a big shift from SCM to DCM. During this change, companies should catch the continuous trend to improve responsiveness and meet specific needs of customers. At the same time, companies are able to achieve cost-efficiency (Christopher et. al., 2006). It is the right time to change strategy and create specialized demand-supply chain models, which are fast, reactive, and designed to meet all customer demands in order to stay competitive. Porter (1996) argued that companies have some problems during alteration process of their strategies. The failures occur in distinguishing between operational effectiveness and strategy. Hilletofth et al. (2009) argues that by developing a supply chain strategy, which is based upon differentiation, is the way to meet varying needs of customers and maintain economies of scale at the same time. Some deductions can be mentioned such as, in order to gain competitive advantage, companies should get a deep understanding of which components should be rearranged in current business environments. It is obvious that changed market environment asks companies for an appropriate strategy in order to find its' own market niche and stay competitive.

When we come to CSFs, it is a crucial activity to define CSFs because they help companies achieving their missions and strategic goals of the organization. Some success factors can be obvious while others invisible. There exists many different definitions for CSFs. Bullen et. al. (1981) mentioned CSFs as not overwhelming in numbers but players of a significant role in the success of an individual, group or organization in a competitive environment. CSF detects performance areas, where managers must continually manage, and the issues, which provide a healthy and vital environment for the organization. CSFs are described as the most important components of strategy implementation. Brotherton et. al. (1996), see CSFs as the vital points that the company must reach or focus on which areas will bring the maximum "competitive leverage". It is very common that CSF are confused with strategic goals, and to avoid this confusion. Brotherton et. al. (1996) emphasize that CSFs are not equal to goals, but they are more related to activities and performing processes that can be administered/affected by managers to achieve goals of the company. Based on the best practices in the market, it is suggested that there should be limited number of CSF, perhaps between five and eight (Parmenter, 2007). Definitions provided by earlier researches have one common feature – they emphasize obtaining a competitive edge.

As Parmenter (2007) pointed out, the need of an organization is to define KPIs in order to focus on aspects, which are the most crucial for the current and further success of the company. Any business, regardless of industry and size, can better manage market

performance with the help of performance measurement metrics (Parmenter, 2007). Bauer (2004) stated KPIs are quantifiable metrics, which reflect the performance of the organization while reaching its goals and objectives. Companies should identify KPIs in the light of CSFs and strategic objectives in order to link actual performance and expected results to CSFs. As Parmenter (2007) argued that KPI should be related to the organization's CSF and objectives to be called as a performance measurement tool. After identification of the right CSFs, it is easy to define KPIs, just because of the reason that they will exist within chosen CSFs. Furthermore; Bauer (2004) adds that all individuals involved in the business processes of organization are moving in the same direction of achieving the same goals and strategies.

Today, due to strong competition, globalization and technology development, firms have no choice but to operate in a changing environment, which leads to dealing with plenty of different performance indicators. This resulted in development of different methods of setting up and prioritizing KPIs. The questions about KPI prioritization and the number of KPIs are the most popular ones in the literature. There should be a limitation on the number of KPIs. No more than 20 KPIs are recommended. Organizations, which have more than 20 KPIs, lack focus and do less than expected (Kaplan & Norton, 1996; Parmenter, 2007). While prioritizing KPIs, it is important to remember that KPIs for a company may differ depending on the nature of the business and its strategy. Nevertheless, literature review suggests that the standardized method is missing for KPI prioritization.

Consumer-driven enterprises must continuously enhance value for a customer by developing value-adding products and services to gain competitive advantage (Hilletofth et al., 2009). Furthermore, selected KPIs may give an idea to customers about companies' way of doing their jobs in order to improve customer service level by increasing value added activities.

METHODOLOGY

A framework for KPI selection in HDV industry was developed to provide in-depth understanding of how the most effective KPIs can be selected from a consumer-driven point of view. The objective is to show the relations between CSFs and KPIs to establish a framework rather than doing any numerical analysis of these concepts.

A stepwise procedure was used from mission statements to KPI selection. In the first step, a sample of mission and vision statements from some companies operating in the HDV industry (Table 1), have been evaluated to provide a foundation for the specification of CSFs in this industry. Some common points between these evaluated statements were found, including value creation according to customers' needs, long-lasting occurrence in the market, innovativeness, and product and service excellence. It is important to note that, mission and vision statements are not enough by themselves for developing CSFs. There are other variables that also affect the characteristics of CSFs.

In the second step, CSFs of a consumer-oriented enterprise in the HDV industry were specified based on the evaluation of mission and vision statements as well as a wide range of literature (Table 2). It can be mentioned that some of the CSFs focus on the customer side (target to achieve missions on customer side), such as responsiveness in new product

development (NPD), speeding up to deliver innovation to the market, developing marketing channels, improving product delivery processes, value creation activities, and increasing level of information sharing with customers. On the other hand, some of the CSFs focus on the company side (target to achieve missions inside company) and are not directly related to customer operations, such as continuous coordination between departments.

In the third step, a CSF characteristics table has been designed (Table 3), including aspects such as requirements, benefits, risk, and limitation of a consumer-oriented enterprise. In essence, this table provides in-depth analysis of the selected CSFs. This analysis has crucial importance, since companies should be aware of that they have proper environment for making strategic decisions.

Table 1: Sample Vision and Mission Statements.

Company	**Vision**	**Mission**
Volvo	To be valued as the world's leading supplier of commercial transport solutions. (Official Website, Accessed: November 2010)	By creating value for our customers, we create value for our shareholders. We use our expertise to create transport-related products and services of superior quality, safety and environmental care for demanding customers in selected segments. We work with energy, passion and respect for the individual. (Official Website, Accessed: November 2010)
Scania	To deliver optimized heavy trucks and buses, engines and services, provide the best total operating economy for our customers, and thereby be the leading company in our industry. (Annual Report, 2009; Accessed: November 2010)	Scania's identity is shaped by its customers and products – vehicles, services and financing – and by the people in the company, their values and working methods. Three core values − "customer first", "respect for the individual" and "quality" − tie the company together and form the basis of Scania's culture, leadership and business success. . (Annual Report, 2009; Accessed: November 2010
Man	To be number one in commercial vehicles and power engineering (Official website, Accessed: November 2010)	The MAN Group places its customers' requirements and expectations at the center of its corporate strategy. Our products and the services that accompany them throughout their entire life cycle are nothing less than high quality. From the very first moment of contact, we respond to our customers' specific requirements and work together with them to create customized solutions. (Official Website, Accessed: November 2010)

Table 2: Modification of critical success factors.

Critical Success Factors	**References**
Responsiveness in new product development in order to achieve competitive advantage - Getting the right product in the right place at the right time - Speeding up to deliver innovation to the market	Childerhouse et.al. (2002), Heikkilä (2002), Jüttner et.al. (2007)
Developing marketing channels that identify specific needs of different customers - Market segmentation - Product and service differentiation	Griffin et al. (1993) , Walters et al. (2004), Al-Mudimigh et.al. (2004), Jüttner et.al. (2006),
Improve product delivery process in full on time to the customers - Increase customer service level	Woodruff (1997), Wang et.al. (2001), Heikkilä (2002), Walters (2008),
Value creation activities at the side of customers that builds loyalty - Customized and innovative products - Brand loyalty - Successful brand image - Value delivery	Treacy et. al. (1993), Mazumdar (1993), Delgado-Ballester et. al. (2000), Walker et. al. (2000), Kumar et. al. (2000),
Increasing level of information sharing with customers - Open communication	Burns (1995), Fundin (2003), Oleksak (2005)
Continuous coordination between departments - Internally - Externally	Dyer et al. (1998), Lambert et. al. (2000), Simatupang et al. (2002), Keller (2001)

Table 3: CSF characteristics table.

CSF	Requirement	Benefit	Risk & Limitations	HDV View
1. Responsiveness in new product development in order to achieve competitive advantage	- Flexibility - Being adjustable	- Catching new potential markets	- Market response to the new product - Lack of experience in both new product and new market	- Improving the product families
2.Developing marketing channels that identify specific needs of different customers	- Local resources (i.e. Local employees & consultancy) with the knowledge of the market	- Successful identification different customers' needs	- Adaptation of the partners/ suppliers to the new strategy of marketing channels	- Segmentation of the market, designing different packages
3.Improve product delivery process in full on time to the customers	1. EDI infrastructure to arrange forward an backward relation - Tracking and tracing progress of the process	- Cost reduction: decreasing the rate of inventory and back-ordered sales, to increase customer satisfaction	- Bullwhip effect - Over promising	- Organizing the delivery related interruptions such as campaigns in a structural way in the case of having problems with suppliers
4.Value creation activities in the side of customers that builds loyalty	Proactive markets research and sensibility to the value creation in the whole supply chain	- Customer base less sensitive to the marketing efforts of competitors reinforcing - The brand image and price policy of the product	- Customers uncertainty or ambiguity in the satisfaction of his/her consumption expectations	- Designing packages in for of offering complete solutions including soft offers for services and extra options for each specific fleet costumer
5.Increasing level of information sharing with customers	- Transparency and systematic information flow	- Faster decision making based on updated facts	- Leakage of information to the competitors/internal and external - Attitude towards sharing information	- Same systems authorization for both costumers and the company
6.Continuous coordination between departments	- Cross-functional integration of departments - A qualified information-sharing system to share required information	- Maximize the potential for converting competitive advantage into profitability - Better technical quality, faster schedule	- Confusion in different role descriptions - Pro-long the project time	- Face to face meetings and updates - Sharing positive results visually in the meeting points of the departments - Planning common activities

In the fourth step, a KPI pool was established. 42 different KPIs were selected based on a wide range of literature (McKinnon et al. 2006; McKinnon 2007; Report: ISA 95, 2006) and own experience. We desired to establish a comprehensive KPI pool, because an industrial firm has a complicated structure and there are many processes. Companies should be able to see different perspectives of these processes and they should be able to make detailed performance analysis. The selected KPIs can be seen in Table 4.

In the last step of the procedure, a KPI value table has been developed (Table 4). In this table each KPI is analyzed according to its correspondence with the selected CSFs in order to identify relevant KPI-CSF pair. In addition, the set of departments that play an important role in integration between the company and its customers is specified. It is important to mention that each department in a company has unique responsibilities and they are indispensable parts of the company. However, some of them have great importance to establish a relationship between company's side and consumer's side. Specification of the departments is a requirement to provide a better understanding while implementing KPIs on the operational level in a consumer-oriented enterprise. This because departments are responsible to implement CSFs and KPIs into the company's processes and the same departments are also responsible to measure the efficiency of KPIs during processes. During selection process of the most important KPIs an empty cell implies that no connection or relation between the KPI and the CSF was found. If they are related, the cell is said to be *tagged* and it contains the list of involved departments. For each KPI-CSF pair, one or more departments have been assigned. The departments considered are as follows: After sales (AS), Business solutions (BS), Logistics (L), Marketing (M), Product development (PD), Sales (S), and Quality (Q)

Table 4: Key performance indicator value table.

KPI	CSF 1	CSF 2	CSF 3	CSF 4	CSF 5	CSF 6
1.Vehicle Fill	PD			PD		
2.Empty running						
3.Fuel consumption				PD		
4. Vehicle time utilization						
5. Reject or return rate on finished products (quality)				AS/Q	AS	AS/Q
6. Actual versus planned volume (order fulfillment)		M/S	S/L	BS/M/L	L	
7. Percentage reduction in the manufacturing cycle time (planning and productivity)	PD		PD/L	PD		PD
8. Production and manufacturing schedule adherence			PD/L	PD		PD/M/S/L
9. Rework and repair hours cost comparing to direct manufacturing (quality)					AS	PD/AS/Q
10. Percentage of the automated assembly steps (engineering and Productivity)	PD		PD/L			PD
11. Hours lost due to technical equipment problem or downtime (assets utilization)			Q			Q/L
12. Hours lost ratio due to material or missing parts (assets utilization)	PD/Q					PD/Q/S
13. Production equipment set-up or availability time and uptime (manufacturing)						
14. Average machine availability rate or machine up-time (asset utilization and manufacturing)						
15. Reject-rate reduction (quality)			L	Q/AS	AS	AS/Q/L
16. Number of process changes per operation due to errors (quality)	PD/Q					PD/Q
17. Percentage increase in output per employee (personnel and staff)			PD			PD/S
18. Percentage unplanned overtime (personnel and staff)			PD			PD/S
19. Safety and security incidents (personnel and						
20. Productivity based on the number of units per labor hour (productivity)			L	PD		PD/L
21. Cost of supplier shortages per period (material and supplier)	Q/PD		PD/Q/L			PD/Q/L/S

22. Variances of the material from standard units for Non-standard vehicles (material and supplier)	PD/BS	M/BS		M/BS	S	S/M/BS
23. Standard order-to-shipment lead time for major products (planning)		M	L	PD/M/L	S/L	PD/M/L
24. Time required to incorporate engineering changes (planning)	PD					S/M/PD
25. Turn around time						
26. Average carbon dioxide emissions of vehicles by its type (environment)	PD	M		PD/BS/S/M		
27. Number of visits of the costumer per month to service centers for repairs: (after market)		M	M	AS/BS	AS	AS/M
28. Parts availability at the service centers (after market)			L	AS/L	AS	L/AS
29. Average production costs of units produced within measurement period.				L/M/PD/S		
30. Average Unit Cost	PD	M/S		L/S/PD/S	L/M/D/PD	
31. Rate of damaged material by error of workers						PD/Q
32. Customer order cycle time based on time from the request to fulfilling the order	PD	M	L/M	S/L	S/L	S/L/M/PD
33. Order to delivery fulfillment measurement	PD	M	L/M	S/L	S/L/M	S/L/M/PD
34. Accuracy in request delivery date, confirmed delivery date, actual delivery date to be the same	PD	M	L	L/S	S/AS	PD/L/S
35. Supply chain cycle time	PD	M/S	L	M/L/S	M/S	PD/M/S/L
36. Ex-work performance						
37. Accurate information on inventory levels			L	S/M	S	S/M/L
38. Availability of all order classes and augmentations	PD	M		S	S/M	S/M/PD
39. Improved customer satisfaction	BS/PD/Q	M/S	M/L	BS/M/L/AS	S/AS/M	AS/L/M/S
40. Lower distribution costs as a percentage of order management costs		M/L	L	S/L		
41. Decreased transportation cycle time		M/L	L		L	M/L
42. Increasing collaboration between dealers and top management	PD/M	M		M/PD/BS	S	PD/BS/S/M

RESULTS & ANALYSIS

As a result of the KPI value table, 17 *tagged* KPIs out of 42 KPIs were identified as the most valuable and measurable guidelines, that can respond to the customers' demands and interests within the HDV Industry on the operational and strategic level. Selection was made between KPIs, which have 6, 5, and 4-tagged cells (Table 5) and they were divided into 3 groups according to number of tagged cells.

Selected KPIs can specifically be used for this industry to meet consumer demands and satisfy their needs. The core expectations of the selected KPIs should stay aligned to help the managers of the companies in the strategic, operational and tactical decision making processes to gain benefits and reach the position of a high performance organization. They can establish a guideline for the enterprises, which desire to become more consumer-driven.

The benefits of selected KPIs can be evaluated from different aspects. These KPIs provide holistic view on the whole demand chain, adaption to consumer-driven philosophy, and

monitoring suppliers in terms of its quality, capability, credibility. The question of what they have in common can be a guideline for the enterprises to become more consumer-driven based on the shifts in the market. There will be made an analysis in the following parts for selected KPIs and excluded KPIs with various reasons.

Table 5: Selected and excluded KPIs.

KPI	6 tags	5 tags	4 tags	Excluded
1.Vehicle Fill				
2.Empty running				X
3.Fuel consumption				
4. Vehicle time utilization				X
5. Reject or return rate on finished products				
6. Actual versus planned volume			X	
7. Percentage reduction in the manufacturing cycle time			X	
8. Production and Manufacturing schedule adherence				
9. Rework and repair hours cost comparing to direct manufacturing				
10. Percentage of the automated assembly steps				
11. Hours lost due to technical equipment problem or downtime				
12. Hours lost ratio due to material or missing parts				
13. Production equipment set-up or availability time and uptime				X
14. Average machine availability rate or machine up-time				X
15. Reject-rate reduction			X	
16. Number of process changes per operation due to errors				
17. Percentage increase in output per employee				
18. Percentage unplanned overtime				
19. Safety and Security incidents				X
20. Productivity based on the number of units per labor hour				
21. Cost of supplier shortages per period				
22. Variances of the material from standard units		X		
23. Standard order-to-shipment lead time for major products		X		
24. Time required to incorporate engineering changes				
25. Turn around time				X
26. Average carbon dioxide emissions of vehicles by its type				
27. Number of visits per month to service centers for repairs		X		
28. Parts availability at the service centers			X	
29. Average production costs of units produced				
30. Average Unit Cost			X	X
31. Rate of damaged material by error of workers				
32. Customer order cycle time	X			
33. Order to delivery fulfillment measurement	X			
34. Accuracy in delivery date	X			
35. Supply chain cycle time	X			
36. Ex-work performance				
37. Accurate information on inventory levels			X	
38. Availability of all order classes and augmentations		X		
39. Improved customer satisfaction	X			
40. Lower distribution costs as a percentage of order costs				
41. Decreased transportation cycle time			X	
42. Increasing collaboration between dealers and top management		X		

The benefits of using the most prioritized KPIs, which have 6 tagged cells, can be put in an order like that gaining a point of view for holistic planning across the chain, adapting consumer-driven philosophy and following its progress internally and externally, monitoring INCOTERMS, suppliers performance, capability, credibility and providing commitment to them in order to be in the same level with the company. Companies should fulfill the requirements of this tough competition to be alive in the market. Level of competition, potential entrants of the market, and changes occurred in customers' needs due to dynamic market conditions are some points that companies take into the consideration.

The second groups of KPI, which have 5-tagged cells, highlight the importance of variation of offers and availability of the services and/or products for customers at right place on the right time. In addition the technological knowledge and innovation will be adding extra value to the variety and quality of the products/services. However, service-minded and reflecting stuff for planning in all levels (from top manager to the technicians) is also evaluated to affect the business.

The third group of KPIs helps empowering the time and price management in sub-categories. Also, they help having accurate and better mechanisms of controlling in planning, cost and time reductions and finding new saving ways (methods), which will lead into improvement of internal manufacturing processes. In addition, the future performance can be improved by using standardized and compiled past data

The last group of KPIs are excluded KPIs. Some KPIs, which are related to the employment conditions and regulations such as safety and security incidents and ex-work performance, might be important in majority of countries, but it is not in focused in the rest of the countries at the same level, therefore the related KPI has not been valued as a relevant option. Consumers' ways of dealing with the products after buying them and the usage purpose of those products have been considered as an external affect in this article. The manufacturing set-up times, machine availability rates, equipment usages and asset utilization may affect the cost indirectly in the matter of process development, but is not having high priority from costumer point of view and for customer satisfaction. For sure, all the aspects have important role in the business' processes but they are not directly related to processes, which are achieved especially for turning the company to more consumer-driven structure. To be mentioned that external activities done by customer and transport companies are out of the short chain that we had defined in the framework of this study.

CONCLUDING DISCUSSION

The critical point is to be able to move on the right path, which helps finding the most efficient KPIs. This study shows that there is a strong correlation and harmony between mission, strategic goals, CSFs and KPIs. In order to develop a consumer-driven structure, all components of the company such as mission and vision statements, strategic goals and objectives, CSFs and KPIs should focus on the same idea. Especially the departments should implement the selected KPIs strictly and also they should measure the current performance periodically. In the light of selected KPIs, companies should be able to satisfy customers' needs with the right product and services at the right time, and adapt themselves to rapid

changes in customer demands. Also they should perform value-added activities on the products with the help of technological knowledge and innovative ideas. In addition, the selected KPIs enable having more accurate control mechanisms in terms of cost and time reductions. Competitiveness is another critical aspect for the companies. The selected KPIs help specifying market opportunities and changes in customer preferences due to market trends in the middle of tough competition. Companies also should keep volatile and fluctuated customer demand in mind. In addition, the updated technological knowledge and innovation will be adding an extra value to the variety of the product range. Additional benefits of the selected KPIs such as providing effective control on accuracy in planning, reductions in cost and time and finding potentials saving areas which will lead to improvement of internal manufacturing processes. It is important to note that the KPIs should be repeatedly measured and their periodical analysis should be done to evaluate the progress of activities, which are executed for customer orientation and satisfaction.

Implication of the research can be grouped under three points such as theoretical implications, practical implications and suggestions for further researches. From theoretical point-of-view, this research targets to fill the gap of knowledge about the development of effective KPIs. Also, this research proposed a guideline with exciting findings relating consumer-oriented CSFs with effective KPIs. From practical dimension, the findings can be applied in the strategic, tactical, and operational planning level of a company to gain the competitive advantage in the market. The proposed framework can provide useful and innovative ideas for the strategic decisions inside the company, e.g., in the new product development and soft offers designing. Also, for decreasing the risk rate involved in the goal setting process, KPI prioritization should be seen from a multi-criteria decision making perspective.

For further research, more detailed investigations can be prepared for the different KPIs with different units and scales. Developing various questionnaires and distributing them among consumers may accomplish this aspect. Some tools for examining and testing the efficiency of KPIs have been proposed in the literature and these could be suggested as further research topics. Analytical Hierarchy Process (AHP) is a powerful tool for decision-making (Saaty, 1980) and, thus may be used in the process of prioritizing KPIs. Furthermore, SMART criteria (Significant, Meaningful, Appropriate, Relevant and Time-bound) are widely used for evaluating objectives and goals of the firm.

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PRODUCTIVITY AND PERFORMANCE MEASUREMENT WITH AN INTEGRATION OF TIME-LAG EFFECTS

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ABSTRACT

According to ISO ISO9001 version 2000 requirement 8 were released methods of analysis to general production and design manufacturing. This work has design to carry out the performance and benefit of R&D in point of financial index on new product to end customer.

It is 4 parameters under Balance Scorecard Concepts in this study; financial perspective, customer perspective, internal process perspective, and innovation and learning perspective. Those parameters have look in single point of view with no inter linkage. Normally, most the top managements have relied on financial data or cost and benefit issues to monitor and control the business with less consideration of other factors such customer analysis, internal process, and innovation and learning. It was found crucial factors that able to improve the financial statement of RPP. The results in terms of mathematics index were confirm the believing of management such over time benefit to RPP, labor cost control, and other un-seen factors. It was found the innovation and learning has reflect to company social quality and derived the by positive product of earning before interest and tax (EBIT).

Keywords: balanced scorecard, key performance measurement / time lag analysis / management process / performance improvement, operation management, modeling.

1. INTRODUCTION

Since the earlier of the year 2008, the oil price was increasing sharply (international energy agency - oil market report; 10 July 2008) and direct effect on plastics business. Absolutely, Any Plastic film production affected directly by this phenomenon. Where, the selling price can not much adjust to the end user such packaging provider, card supplier, advertisement business, and others who use a Rigid film as an intermediate. So the role of Key Performance Measurement becomes an important role to monitor and control each of involved facility to; meet the plant optimality; and meet the global customer requirement.

Most organizations now faced on opportunities, threats, and change on an unprecedented scale. Decision making is seen as synonymous with management (Simon, 1977). It affects the actions through the whole operational process and determines the level of management success in any organization (Kurstedt, 1992).

The quality of a decision is based on the experience of the decision maker and supporting information. According to Kaye (1995), a decision is made on the basis of hunch and intuition, but is legitimated by dressing it up with supporting facts and data. Longbottom (1672) and Mintzberg (1976) advocated that effective decision making occurs where managers actively select situations which require decisions and seek information regarding those decisions. Forrester (1961) also suggests that the level of success in decision making primarily depends on information since decision making is the process of converting information into action. Therefore, good information is necessary for decision making. If an organization is to survive and prosper, it must understand both its own internal workings and the nature of the environment to which it has to adapt and respond (Kaye, 1995). Thus, good information should reflect both internal processes and external agencies such as governments, competitors, and social groups.

Refer to Phusavat K. *et al*., (2007), the organization data was study in terms of internal relationship of productivity, quality of work life on each accounting parameter finally the data were kept as a data base to monitoring and control the business. Where, statistics and mathematics were applied. The study is conducted to help address the concern of the company's top management and the FG management team on how to demonstrate their ISO 9001:2000 compliance and TQA commitment. The lessons from the impacts from the existing customers, as well as the potential benefits from new customers, are summarized. The changes in the company paradigm on the roles of the existing customers and its sales workforce have emerged.

Appropriate PM need to be aligned with the organization's strategy. It should lead to attainment of strategic goals and impact on the goals and strategies needed to achieve them (Dixon *et al*., 1990). Among the most popular PM systems is the balanced scorecard (Yeniyurt, 2003). The Balanced Scorecard Concept (BSC), developed by Kaplan and Norton (1996), is a widely used management framework for the measurement of organizational performance which evaluates both financial and non-financial perspectives. It suggests that the state of process of an organization can be best assessed by taking a "balanced" view across a range of performance measures. This paper studies the relationship between financial and customer perspectives as suggested in the BSC in an attempt to provide analyzable information for management to improve the quality of decisions. In this study, the case study business unit is the plastic resin conversion factory which locates in Thailand. This plant may called Rigid Plastic Production Plant or RPP. It's organization is consisted of production, ware house, and logistics department; technical department (R&D); and maintenance department. All departments are under plant manager, general manager, and top management of petrochemical business group.

2. PROBLEM BACKGROUND

There are two critical problems facing the management team at the RPP. The first one is the management want to know how is the time lag effect of new products which derived by R&D department to out put such new revenue from a new customer. Second, the data which related to ISO 9000 version 2000 item 18 does not much fit to a current system. The key performance measurement has done by each department. For example financial

department look at the financial status, human resources management look at working overtime, leave, cost of development. Where those key performance measurement does not represent total company performance. So the RPP managements want to know in depth of the detail to improve the quality objectives. Over the past few years, the term performance-based management has gained more attention among SMEs, manufacturing, trading, and government sectors in Thailand due to the need to comply with Requirement 8 of ISO 9001:2000. This requirement stresses the explicit linkages among performance measurement, analysis and improvement. Complying with this Requirement 8, especially between measurement and analysis, cannot simply be achieved through technical investment alone. It is important to note that the certification of ISO 9001: 2000 is recognized as a necessity for enterprise development, customer acceptance and market access in the globalisation period.

During the time of study, the RPP management givens financial information and R&D information collected by the accounting department and R&D/Production department but they never did analysis for interrelation ship on it. Refer to financial information and R&D data; there are no other intangible factors such as product satisfaction or service quality, customer satisfaction, or employee morale, collected. The lack of information assessment and the failure to collect the information aligned to the organization's goals result in many unsolved strategic problems as mentioned above.

3. OBJECTIVES

The purposes of this study are assess the suitability of information currently collected and used in an organization and assess and evaluate the usefulness of the results of performance analysis in improving the quality of management's decision making. Where the decision make factors have derived from mathematical analysis. This recommendation target to ensure that key performance measurement under internal relationship from balance scorecard method able to illustrated the company figure. The expected impacts from this research are the improvement of the RPP management process and to prepare the the ISO 9001: version 2000 application.

4. METHODOLOGY

It was several steps to execute during this study. The first important step is to determine the possibility of completing the management process as stated and required by ISO 9001:2000. It can be described as follows.

4.1 Grouping and rearranging the existing Key Performance Indicators (KPIs) into Balanced Scorecard (BSC) framework.
4.2 Identify the information to be tested.
4.3 Collect information from the RPP.
4.4 Examine and establish the possible relationships between the financial, R&D, and the customer perspectives information.
4.5 Analyze the appropriateness of the information based on the examining results together with R&D section manager.

4.6 If the information is inappropriate; establish a new set of performance metrics to be measured based on the BSC.

4.7 Interview the management team at RPP to assess the usefulness of the analysis results and the new set of performance metrics in terms of the attempt to improve the management's decision making process.

4.8 Report the results in written literature.

4.9 Release methods of analysis to RPP to use in further as a requirement of ISO9001:2000 requirement 8.

RESULTS AND DISCUSSION

Refer to methodologies of regression, Table 1 represent for given financial data, customer issues, internal process, innovation and learning. It was selected to plot in single and multiple model. Where, Table 2 is a result for simple regression model, Table 3 for polynomial regression model, and Table 4 for multiple regression model. To study time lag effect the statistics and mathematics is required. Thus, the agreed conditions for an model's development are identified and finalised together with the RPP management team. A selected model is based on p-value < 0.3, Adj-R2 > 70% and VIF < 5.0 (for a multiple regression model). The variance inflation factor (VIF) is used to detect whether one predictor has a strong linear association with the remaining predictors (the presence of multicollinearity among the predictors). VIF measures how much the variance of an estimated regression coefficient increases if predictors are correlated (multicollinear).

Table 1: The common KPIs data collection based on Balanced Scorecard.

Financial	*Customer*	*Internal Processes*	*Innovation and Learning*
F1 = Interest per man-day cost (Baht/Baht)	C1=New customer per total customers (%) (Based on 100 number of December 2007)	IP1 = On time sample delivery (%)	IL1 = R&D cost per new products order intake (Baht/Baht)
F2 = Revenue per trial order (Baht/Baht)	C2 = Claim per total claim of each year (%)	IP2 = Output per head (Tons/head)	IL2 = Bonus per salary (%)
F3 = EBIT per number of R&D staffs (Baht/head)	C3 = Number of customer complaint per month (Time/Month)	IP3 Product quantity (tons)	IL3 = Over time per salary (%)
F4 = Revenues from new product per total revenue (%)	C4. Successful order (Approved Art Work) per total order (%)	IP4 = Labor cost (Baht/Kilogram)	IL4 = Welfare per salary (%)
F5 = Revenue per raw material cost (Baht/Baht)		IP5. Labor Cost per production output (Baht/Kilogram)	IL5. Marketing expense per customer (Baht/customer)
		IP6 = Yield (%)	IL6. Investment in new product per R&D staff (Baht/head)
			IL7 = Employee training cost per number of employee (Baht/head)

Note : 35 Baht is approximately equivalent to 1USD.

Table 2: The information from RPP for financial perspective.

	Financial perspective				
Period	*F1*	*F2*	*F3*	*F4*	*F5*
January 2007	221.83	N/A	194	N/A	1434
February 2007	257.58	N/A	-97	N/A	1444
March 2007	268.64	N/A	-102	N/A	1721
April 2007	240.00	N/A	-25	N/A	1720
May 2007	282.21	N/A	-102	N/A	1573
June 2007	230.67	N/A	-309	N/A	1497
July 2007	209.33	N/A	-202	N/A	1751
August 2007	214.12	N/A	-191	N/A	1261
September 2007	252.52	N/A	-187	N/A	1537
October 2007	224.92	N/A	69	N/A	1711
November 2008	223.09	N/A	-43	N/A	1345
December 2008	233.49	N/A	-58	N/A	1724
January 2008	245.77	146.36	33	1%	1869
February 2008	220.41	942.97	-138	4%	1685
March 2008	236.24	137.92	-194	3%	1570
April 2008	197.99	167.03	-71	5%	1675
May 2008	190.89	43.59	-108	3%	1523
June 2008	201.86	85.51	27	8%	1590
July 2008	208.64	213.04	-65	5%	1407
August 2008	214.16	341.10	-58	16%	1620
September 2008	160.36	246.23	-305	3%	1332
October 2008	145.81	331.57	-452	7%	1209
November 2008	154.40	283.82	-415	3%	1296
December 2008	164.53	82.64	-512	6%	1103

Note : N/A is no data available during this period.

Table 3: The information from RPP for customer perspective.

	Customer perspective			
Period	*C1*	*C2*	*C3*	*C4*
January 2007	N/A	5%	2	N/A
February 2007	N/A	4%	0	N/A
March 2007	N/A	8%	1	N/A
April 2007	N/A	0%	0	N/A
May 2007	N/A	5%	15	N/A
June 2007	N/A	21%	14	N/A
July 2007	N/A	15%	10	N/A
August 2007	N/A	15%	15	N/A
September 2007	N/A	2%	3	N/A
October 2007	N/A	8%	12	N/A
November 2008	N/A	7%	9	N/A
December 2008	N/A	10%	2	N/A
January 2008	5%	13%	10	12
February 2008	8%	4%	7	25
March 2008	4%	7%	10	47
April 2008	8%	7%	7	65
May 2008	10%	6%	9	85
June 2008	10%	11%	13	100
July 2008	7%	28%	5	100
August 2008	10%	13%	5	100
September 2008	6%	13%	11	100
October 2008	10%	0%	8	100
November 2008	7%	0%	0	100
December 2008	5%	0%	0	100

Note : N/A is no data available during this period.

Table 4: The information from RPP for internal processes perspective.

	Customer perspective					
Period	*IP1*	*IP2*	*IP3*	*IP4*	*IP5*	*IP6*
January 2007	91.8	5%	2	N/A	N/A	N/A
February 2007	91.8	4%	0	N/A	N/A	N/A
March 2007	91.8	8%	1	N/A	N/A	N/A
April 2007	91.8	0%	0	N/A	N/A	N/A
May 2007	91.8	5%	15	N/A	N/A	N/A
June 2007	91.8	21%	14	N/A	N/A	N/A
July 2007	91.8	15%	10	N/A	N/A	N/A
August 2007	91.8	15%	15	N/A	N/A	N/A
September 2007	91.8	2%	3	N/A	N/A	N/A
October 2007	91.8	8%	12	N/A	N/A	N/A
November 2008	91.8	7%	9	N/A	N/A	N/A
December 2008	91.8	10%	2	N/A	N/A	N/A
January 2008	91.8	13%	10	12	12	12
February 2008	62.0	4%	7	25	25	25
March 2008	96.9	7%	10	47	47	47
April 2008	97.2	7%	7	65	65	65
May 2008	98.71	6%	9	85	85	85
June 2008	92.31	11%	13	100	100	100
July 2008	92.75	28%	5	100	100	100
August 2008	97.26	13%	5	100	100	100
September 2008	98.08	13%	11	100	100	100
October 2008	98.51	0%	8	100	100	100
November 2008	97.96	0%	0	100	100	100
December 2008	96.07	0%	0	100	100	100

Note : N/A is no data available during this period.

Table 5: The information from RPP for innovation and learning perspective.

	Innovation and learning						
Period	*IL1*	*IL2*	*IL3*	*IL4*	*IL5*	*IL6*	*IL7*
January 2008	60%	8%	8%	6%	0	25753.30	0.00
February 2008	3%	8%	13%	3%	229	3651.46	3.76
March 2008	29%	8%	8%	8%	32	22575.76	48.87
April 2008	13%	8%	7%	2%	92	21096.87	0.00
May 2008	90%	8%	5%	7%	43	73114.86	0.00
June 2008	16%	8%	7%	5%	269	38910.86	7.52
July 2008	10%	8%	0%	8%	51	14335.53	0.00
August 2008	2%	8%	7%	4%	48	10740.56	0.00
September 2008	15%	8%	4%	8%	17	12998.13	15.04
October 2008	5%	9%	5%	5%	392	8551.27	3.76
November 2008	12%	8%	3%	9%	168	10177.53	101.50
December 2008	24%	-95%	5%	29%	114	23801.85	0.00

Table 5: The results from the simple regression model.

	Relationship	p-value	Adj-R2 (%)
F1	487 - 20.1 IP4	0.000	79.7%
F2	2119 - 20.02 IP1	0.000	70.0%
F3	252.5 - 39.70 IP5	0.000	70.5%
F5	2016 - 47.38 IP5	0.000	71.4%

As a results from Table 5, the RPP R&D management need to see in case of this study is the finance perspective F4 (Revenues from new product per total revenue (%)) and IL1 (R&D cost per new products order intake (Baht/Baht)). This preferred relationship will answer the top management of RPP for the return of investment on R&D cost for new products. However, it did not found any relationship between these expected two parameters.

Table 6: The results from polynomial regression model.

	Relationship	p-value	Adj-R^2 (%)
F1	677.5 - 47.32 IP4 + 0.954 $IP4^2$	0.000	79.5%
F1*	397.5 - 29.15 IP5* + 0.8765 $IP5*^2$	0.001	74.4%
F2*	8823 - 194.7 IP1* + 1.090 $IP1*^2$	0.000	81.8%
F3*	- 224.4 + 44.06 IP5* - 3.275 $IP5*^2$	0.000	71.4%
IP1*	91.36 + 378.8 IL3* - 4586 $IL3*^2$	0.000	94.6%

Note : * Meant the data is account only in fiscal year 2008 for none * mean the data from fiscal year 2007 and 2008 was accounted in regression.

Refer to Table 6 the results from polynomial regression; it was found that IP4 has effect on F1 at significance level. IP4 has the average points during 11-14 Baht/Kg. As per discussion with the management of RPP, the F1 that the RPP need is the lower the better to operate this kind of business where the IP4 has to concerns at the optimum point. For this case it hard to point out which is the optimal point for F1 and IP4 on operation. The higher IP4 the lower F1, where IP4 can not go at thigh value due to it will effect on products base price.

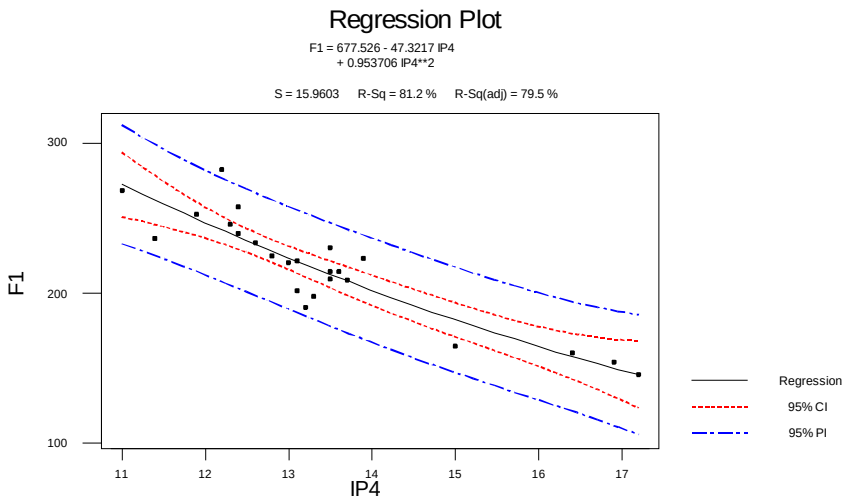


Figure 8 Regression plot IP1 and F1 for polynomial model

So for this case, the management did agreement to do so the operation point must control during 11-14 for IP4, while accepted F1 is ranging from 200-300 Baht/Baht. According to polynomial regression model between IP5 and F1, it was found the bottom of polynomial plot for IP5 value at 17 Baht/Kg and F1 at 155.26 Baht/Baht. This bottom point is mean if the IP5 value going high than 17 Baht/Kg, the production yield is going worse due to production output less production manager expectation, design value is ranging from 11-17 Baht. For financial perspective F1, the interest rate for capital investment, the management needs to minimize this value as much as possible. However, it related direct to labor cost and production cost for RAW material, the accounting system of RPP is account all cost for production to be terms of loan. So the interest rate has involved in every unit that able to count for money. Refer to Figure 9, the F1 touch down at the bottom line at 155.26 which can not reduce any more in term of cost-saving for interest rate.

Refer to Table 6, it was found the relationship between IP1 (On time sample delivery (%)) has influent on F2 (Revenue per trial order (Baht/Baht)). The polynomial model for IP1 and F2 is representing for the bottom line of operation figure. The relationship between IP1 and F2 is also representing for the success of R&D to effort the company income. The RPP top management is prefer to see the value of F2 as much as possible. F2 will reflect to revenue of the factory each of period during new released products from R&D sector. Refer to Figure 10, it was found that fast response does not mean higher in revenue but it is mean fast in customer response for secured order.

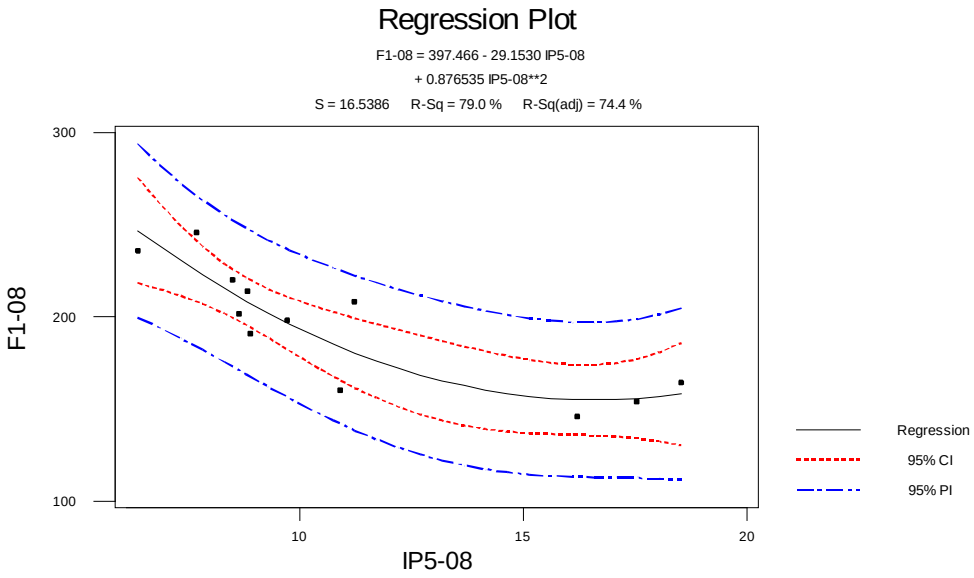


Figure 9: Regression plot IP5-08 and F1-08 for polynomial model.

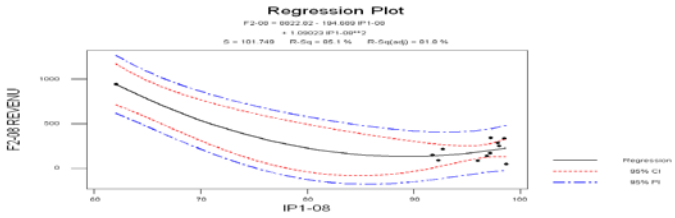


Figure 10: Regression plot IP1-08 and F2-08 for polynomial model.

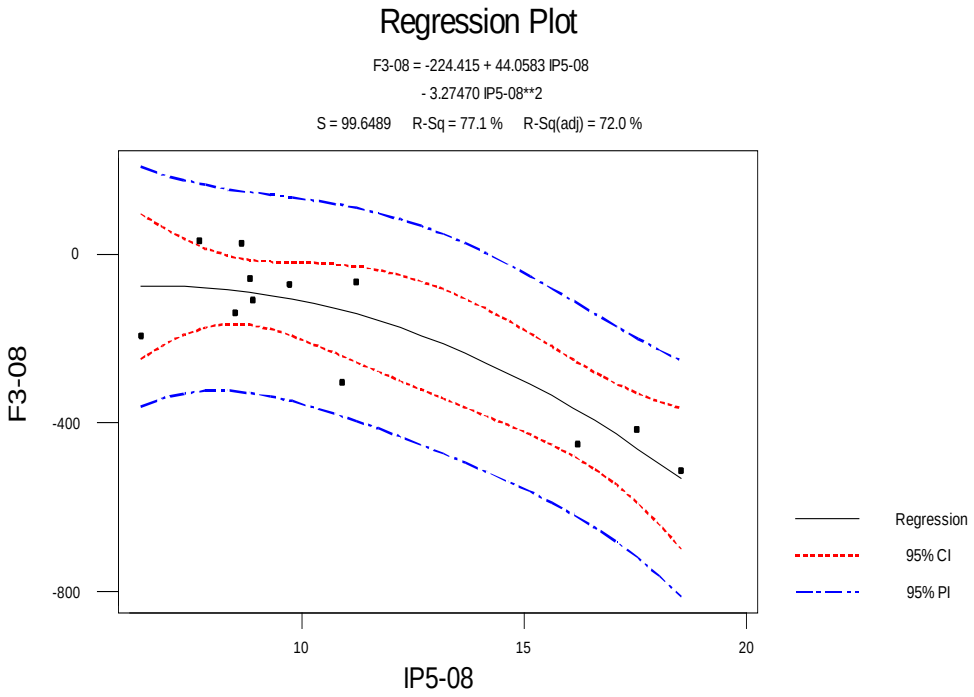
On the other hand the higher revenue F2 in Figure 10 was derived from a complicated formulation product which has large quantity of order from end customers. The response time for the complicated product leads R&D sample preparation officer did slow in sample preparation. A new sample request from end customer need to re-formulation and test for physical properties based on end customer requirement. Several trial orders have to given up due to the complicate of the formula and the specifications are not meet the requirement.

Refer to financial perspective; the EBIT is the most important for business operation. According to polynomial plot model between F3 (EBIT per number of R&D staffs (Baht/head)) and IP5 (Labor Cost per production output (Baht/Kilogram)) for the plot, it was fitted based on division criteria only for the data which done during fiscal year 2008. During fiscal year 2008, world economic was under crisis which derived from the United State of America sub-prime problem. The sub-prime problem was effected directly to Thai economic with out any abstain.

For the period fiscal year 2008, RPP EBIT is a bit higher or less than zero which mean the company getting worse from the economic situation. IP5-08 in any value cannot fulfill the company profit F3-08. However, refer to Figure 11 the best way to maintain the business profit to minimize lost in EBIT; the production section has to produce more goods at

maximum capacity, where the IP5-08 region is around 7-10 Baht/Kg. It is possible to monitor and control IP5 to let F3 on positive value. Figure 12 is representative for successful IP5 control to let F3 getting positive value. Figure 12 is point for the region that monitored IP5 to support F3 to get positive

Figure 11: Regression plot IP5-08 and F3-08 for polynomial model during year 2008.



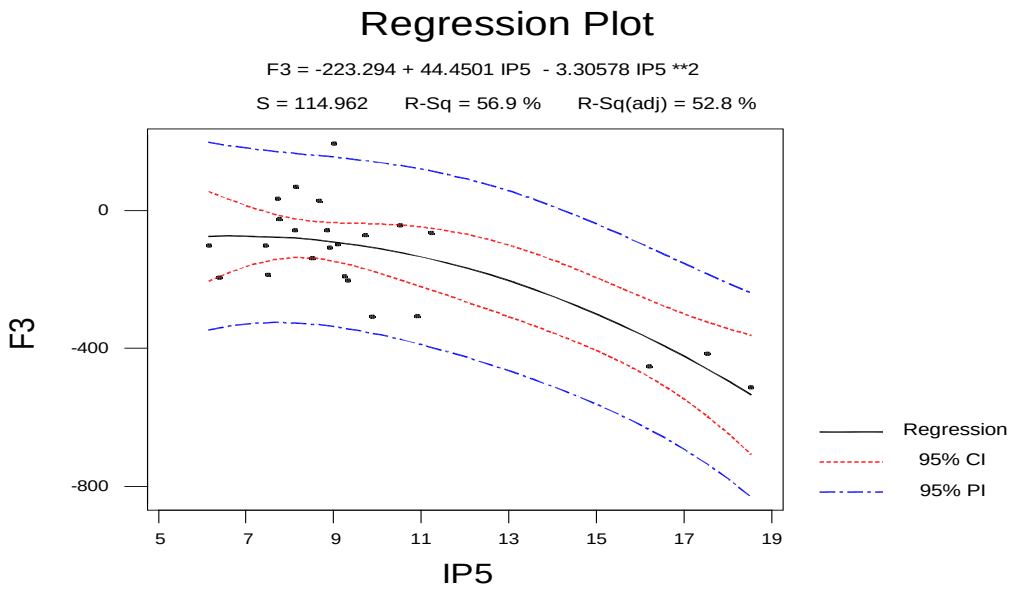


Figure 12: Regression plot between IP5 and F3 for polynomial model during year 2007-2008.

The optimal values are ranging from 7-9 for IP5 to let F3 to be in positive value. However, Figure 12 is un-qualified model based on model selective criterion. So the Figure 12 is use only for monitoring only. Refer to Table 6 it was also found the relationship between IL3 (Over time per salary (%)) and IP1 (On time sample delivery (%)). Working overtime is not preferred too much from the top management of RPP except the order that has large quantity and quality guarantee of products are committed to customers. According to polynomial model plot between IL3 and IP1 for fiscal year 2008, it was carried out for maximum IP1-08 at 99.20% where IL3-08 is at 0.04. As a result, the over time is no need to apply for the response of customer on time delivery. Even though the operator work only standard working hour (12 hours/shift), IP1 at 91.35% is still accepted by the management of RPP. This result is support to a real working life. At RPP, the employee for production line is work for 8 hours standard with special additional 4 hours for extra wages. So that max capability of workers was completely included for productivity. The data from IL3-08 is included for office employee overtime wage. The normal office hour for office worker (white collar) is standard 8 hours which starting from 8:00 to 17:00 in the evening. Refer to Figure 3, the optimal over time for white collar worker is no more than 4% of 8 hours or half an hour/day on average for all employee (265 Man). On the other point of view with multiple regression model results in Table 7. It was found that many parameters which represented in balanced scorecard with combination are reflected to finance perspective. As a result, the combination of IP4 (Labor cost (Baht/Kilogram)) and C2 (Claim per total claim of each year (%)) is play the important role for F1 (Interest per man-day cost (Baht/Baht)). The model F1 = 486 + 0.016C2 - 20.1IP4, means the increasing of IP4 where C2 is constant. It makes F1 decreasing significantly. While IP4 is constant, the increasing of C2 is not much effect on F1. In actual the increasing of C2 will effect to customer trust or the quality of goods. This result agrees with simple regression between IP4 and F1, where the increasing of IP4 is converse to F1 value.

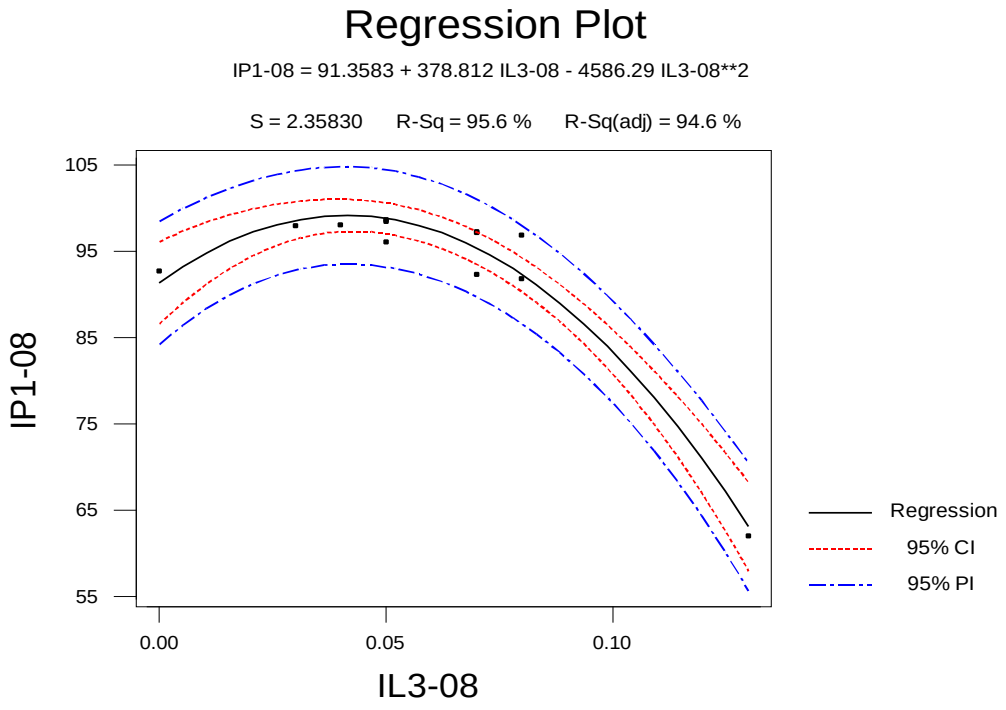


Figure 13: Regression plot between IL3-08 and IP1-08 for polynomial model during year 2008.

The combination between IP1 and IP4 is also effect on F1 value, model F1=507 - 0.270IP1 – 19.8IP4. Where the increasing of IP4 and IP1 lead to decreasing in F1, while IP4 has more important effect than increasing of IP1 in value. To consider the combination between IP3 (Product quantity (tons)) and IP4, the increasing of IP3 leads to increasing of F1 in contrast with the increasing of IP4. In fact the more products output mean the more capital cost that RPP has invest in raw material, so the production output is accounted in terms of interest rate expense together. See IP4 (Labor cost (Baht/Kilogram)) and IP5 (Labor Cost per production output (Baht/Kilogram)) combination, the increasing of IP4 and IP5 lead F1 to deduct in value. IP4 is normally fixes for all operation year but the IP5 is varied by the production output tons/month. It is representing to the management of RPP for 'to control the interest rate effect the output has to maintain at a high level as much as possible'. High production output is induce IP5 lowering in value and leads the F1 lower based on the relation accordingly. Similar IP4 (Labor cost (Baht/Kilogram)) and IP6 (Yield (%)) combination is effect on F1 at the same trend.

Table 7: The results from the multiple regression model for F1 group.

	Relationship	p-value	Adj-R2 (%)
F1	486 + 0.016C2 - 20.1IP4	0.000	78.7%
F1	507 - 0.270IP1 - 19.8IP4	0.000	79%
F1	455 + 0.0106IP3 - 18.9IP4	0.000	79%
F1	468 - 17.7IP4 - 1.37IP5	0.000	79.2%
F1	1006 - 20.6IP4 - 5.51IP6	0.000	79.2%
F1*	431 - 1.15C1* - 16.1IP4*	0.000	85.2%
F1*	299 - 3.85C1* - 6.80IP5*	0.000	85.2%
F1*	237 + 1.98C2* - 0.750C4*	0.000	71.4%
F1*	408 + 0.612C2* - 15.5IP4*	0.000	86.9%
F1	329 - 3.93C3* - 9.60IP5*	0.000	84.5%
F1*	407 - 0.237C4* - 13.8IP4*	0.000	84.5%
F1*	280 - 0.381C4* - 5.00IP5*	0.001	75.1%
F1*	371 + 4.96IP2* - 14.3IP4*	0.001	86%
F1*	438 - 17.1IP4* - 13.4IL1*	0.000	85.7%
F1*	420 - 16.0IP4* + 16.8IL2*	0.000	87.3%
F1*	416 - 15.9IP4* + 56IL3*	0.000	87.3%
F1*	423 - 15.8IP4* - 0.660IL4*	0.000	86.8%
F1*	422 - 16.0IP4* - 0.0145IL5*	0.000	84.8%
F1*	457 - 17.9 IP4* - 0.000436IL6*	0.000	91.2%
F1*	428 - 16.6IP4*+ 0.046IL7*	0.000	84.7%

Note : * Meant the data is account only in fiscal year 2008 for none * mean the data from fiscal year 2007 and 2008 was accounted in regression.

The increasing of IP4 and IP6 leads F1 to reducing in its value. Where increasing of IP4 has higher effect than increasing of IP6 about 4 times/unit. Refer to simple regression model and polynomial regression model, IP6 is not present for any internal relation to the financial perspective, but for the multiple regression model products yield has relative important to financial interest. Higher yield mean higher in good product output from processing unit, it is make production line do optimum cost based on financial designed (labor cost/kg), the

loss in energy, labor, time, and material are minimized. Thus the interest cost (F1) by accounting calculation for loss in capital cost has minimized at the same time.

Innovation and learning perspective has effect to F1 as it represent in Table 7. where the combination of IP4 is involved. As a results, IL1 (R&D cost per new products order intake (Baht/Baht)), IL4 (Welfare per salary (%)), IL5 (Marketing expense per customer (Baht/customer)) and IL6 (Marketing expense per customer (Baht/customer)) lead the result in reducing of F1 in value, when it is increasing in value. However, the number of IL5 and IL6 can be negligible due to the multiplier is small in number. In contrast with the combination between IP4 and IL2 (Bonus per salary (%)), IL3 (Over time per salary (%)), and IL7 (Employee training cost per number of employee (Baht/head)) effect on F1, it given the positive results to F1. The most effect that given the F1 in positive value are IL2 and IL3. As usual on accounting system IL2 and IL3 have accounted for expense. So some interest rate has applied to IL2 and IL3. In this moment, the new data that keep during fiscal year 2008 has play some effect to financial perspective. Therefore, to monitor and control for F1 innovation and learning perspective able to adjust F1 in some degree. Where the RPP management has to use those new parameters from innovation and learning to adjust the financial perspective (F1) in proper conditions and proper time. The above results for F1, is only guide line for monitoring and control of business direction. In actual it must use together with the management experience to do double check with achieved data and results.

Table 8: The results from the multiple regression model for F2 group.

	Relationship	p-value	Adj-R2 (%)
F2*	1727 - 22.3IP1* + 43.2IP4*	0.000	79.5%
F2*	7921- 22.9IP1* - 59.2IP6*	0.000	72.6%
F2*	2030 - 18.4IP1*- 283 IL1*	0.000	77.9%
F2*	1983 - 17.4IP1* - 0.00470IL6*	0.000	77.9%

Note : * Meant the data is account only in fiscal year 2008 for none * mean the data from fiscal year 2007 and 2008 was accounted in regression.

According to Table 9 it was found the relationship between internal process perspective combination and innovation and learning perspective. The combination which effect to F2 (Revenue per trial order (Baht/Baht)). F2 is the most RPP management need to see for the advantage of new material design from R&D department under cooperative with production department. The models in Table 8 are based founded with IP1 which it has similar trend. The increasing of IP1 (On time sample delivery (%)) make F2 a little deduction in value. IP1 value in decimal increment for all F2 model has play a little role for F2 value. However, in fact if the value of IP1 is less than 50% or 0.5 in model, it is possible to make RPP faced on problem for customer trust. The other internal process effect on F2, it is IP6 (Yield (%)), the increasing of yield deduct the value of F2 maximum at 59.2.

This relationship is not mean the lower yield the better in F2. Production manager are normally concern of percentage of yield (Output good products/Input Raw Material). Higher yield means higher in production out put for good products. Refer to Table 8 it was only found two parameters from innovation and learning, which effect on F2. It is IL1 (R&D cost per new products order intake (Baht/Baht)) and IL2 (Bonus per salary (%)). IL1 is the most effective factor to rise up or rise down the F2 value. In real life if R&D cost going high, it is

absolutely effect on revenues. Where, the trial order cost which is dividend of revenue from total products will going high. Thus the F2 is going small in this case. Effect of IL6 on F2 is completely infinitesimal amount to overall F2 with IP4 combination. IL6 is a representative for new products investment, which means the company concern in innovation point of view.

In the innovation company such software computer, computer hardware, and short life cycle products company; the value of IL6 is crucial important on company revenue. Event the IL6 is trivial factor on F1; the RPP managements are still concern for long term of employee development. Refer to the act of Ministry of Labor and Social Welfare, the training course able to deduct for TAX at 200%. If the accounting system by RPP has changed for employee training expense to employee training income, the IL6 will change F1 on positive site.

Table 9: The results from the multiple regression model for F3 group.

	Relationship	p-value	Adj-R2 (%)
F3*	126 + 16.5C1*- 39.4 IP5*	0.001	71.7%
F3*	123 + 6.94C2* - 33.4IP5*	0.001	75.4%
F3*	811 - 70.8IP4* + 273IL2*	0.001	71.9%
F3*	850 - 66.8IP4* - 12.4IL4*	0.001	74.3%
F3*	3530 - 42.8IP5* - 34.7IP6*	0.002	70.9%
F3*	359 - 43.7IP5* - 1030IL3*	0.002	70.0%

Note : * Meant the data is account only in fiscal year 2008 for none * mean the data from fiscal year 2007 and 2008 was accounted in regression.

According to Table 9, it is representative for interrelationship between BSC parameters on F3 (EBIT per number of R&D staffs (Baht/head)). the combination between C1 New (customer per total customers (%)) and IP5 (Labor Cost per production output (Baht/Kilogram)), C1 is given the positive site on F3, while IP3 is given negative site on F3. C1 is clearly shown that new customer able to enhance RPP revenue significantly. In general, to increase the numbers of new customer products and marketing cost (IL5) have to strongly invest. However, the increasing value of marketing cost will lead interest cost increasing unavoidably. When the RPP managements were consider between C1 and IL5, the decision to make profit to RPP is increasing number of C1 instead of IL5 concerning.

Refer to Table 9 the combination of C2 (Claim per total claim of each year (%)) and IP5 (Labor Cost per production output (Baht/Kilogram)), it is also effect to F3 value. C2 tend to increase the F3 value, in fact it is contra with management feeling, but the model state only in percentage level. C2 is claim in percentage of each month compare to total claim of each year. R&D and production department is not need to re-claim process occurred. Due to, most of customer of RPP locate outside Thailand, if the loss due to re-claim products means the lost of those goods which included labor cost, raw material cost, logistics. To take the goods back to recycle from over sea can not meet the economic cost.

Table 10: Claim summary from RPP, collection from fiscal year 2008.

Technical Claim		Commercial Claim	
Problem	Time	Problem	Time
Thickness	4	Key with wrong price	20
Stick Mark	-	Special Price	-
Black Spot	1	Customer Cancel Tax Invoice	-
Oil Mark	2	Issue Over P/O	-
Color	8	Weight	-
Scratch	-	Communication (Sales & Customer)	7
Snow	1	Delay of Shipment	1
Wrinkle	-	Damaged During Transportation	5
Wavy Edge	3	Loss (Transportation)	1
Fish Can	-	Accident (Transportation)	-
Size	-	Tax Invoice	5
Embossing Shrinkage	-	Other	2
Loss Roll	-		
Vacuum	1		
Heat Shrinkage	2		
Weight	-		
Squareness	-		
Take-Off Mark	3		
Wrong Packing	1		
Static	-		
Lamination	4		
Printing	1		
Other	-		
Total	31	Total	41

Top three of claims are key in wrong price (commercial), miss match color (technical), and communication break down (commercial). Those claim, if it is accounted for value. It is about 20,000,000 Thai Baht. From this study, claim value can reduce under increase training, working more concentrate on each order, and also the managements have to supervise for the important order. On the other hand, IP5 provide the negative site to F3, when its increasing in value. The more products out put in kilogram, the lower IP5 value, then F3 (EBIT) is increase later.

The result from the combination between IP4 (Labor cost (Baht/Kilogram)) and IL2 (Bonus per salary (%)) on F3 is shown that IP4 deduct the value of F3 while IL2 enhance the value of F3. If the labor cost in creasing, absolutely it defect on EBIT due to cost of production or cost of goods sold caused higher in price. Bonus over salary in percentage is able to enhance the value of F3 where that maximum value is 25% or 3 months bonus. It is true that, when the end of each year, the employee normally waiting for bonus which announced by the RPP management. In psychology point of view bonus is motivation tool to enhance the employee morality to make them eager to work, to eager to put the force in their own function, and to put a strong intention of own task. Finally, IL2 is a benefit to RPP in all rounds.

Result for the combination of IP4 and IL4 (Welfare per salary (%)) effect on F3, the result shown that IL4 given the negative value to F3 when its increasing. In RPP accounting system, welfare is the expense or cost of management. So it was effect in negative site for EBIT (F3).

For the IP4, it has a similar result to another combination of BSC parameters that discuss in above.

The result for IP5 (Labor Cost per production output (Baht/Kilogram)) and IP6 (Yield (%)) combination on F3, both IP5 and IP6 given a negative site for F4 when it increasing in number. IP6, increasing only in percentage level which ranging above 90%. Yield (IP6). So to maintain F3 on track, the only IP5 will take in charge for monitoring and control. To control value for IP5, the RPP managements have to minimize IP5 by increasing production output as much as possible.

To analyses the F3 under the effect of IP5 (Labor Cost per production output (Baht/Kilogram)) and IL3 (Over time per salary), it is given the negative trend for increasing both IL3 an IP5 in number. Labor cost which design by RPP management for entire of business year is direct effect to EBIT. Over time is a special labor cost is also effect to EBIT. In this case of combination, the management can do monitoring and control only for control the employee over time to maximize F3 value.

Table 11: The results from the multiple regression model for F5 group.

	Relationship	p-value	Adj-R2 (%)
F5*	2219 - 13.4C3* - 57.1IP5*	0.001	71.6%
F5*	1142 - 2.98C4* + 0.425IP3*	0.002	70.2%
F5*	2085 - 2.53C4* - 35.9IP5*	0.000	79.7%
F5*	2297 - 3.28IP1* - 45.2IP5*	0.002	70.8%
F5*	2267 - 25.5IP4* - 37.7IP5*	0.002	70.0%
F5*	2693 - 85.3IP4* + 326IL2*	0.001	74.2%
F5	2735 - 79.6IP4* - 15.8IL4*	0.000	80.4%
F5	1846 - 41.0IP5* + 1644IL3*	0.001	73.3%
F5	1991 - 41.0IP5* - 5.99IL4*	0.002	70.9%

Note : * Meant the data is account only in fiscal year 2008 for none * mean the data from fiscal year 2007 and 2008 was accounted in regression.

Refer to Table 11, the combination of C3 (Number of customer complaint per month (Time/Month)) and IP5 (Labor Cost per production output (Baht/Kilogram)) given the negative sign on F5 (Revenue per raw material cost (Baht/Baht)). High volume in customer complaint mean lower in income, while the RPP lost in opportunity to make profit from raw material via conversion. Because of during complaint the customer normally suspended the further order.

To consider C4 (Successful order (Approved Art Work) per total order (%)) and IP3 (Product quantity (tons)) combination effect on F5, C4 was given positive sign to F5 in contrast with the increasing of IP3. Similar result when combine C4 and IP5 (Marketing expense per customer (Baht/customer)) , C4 was given negative result. However, IP5 is given enormous negative sign for F5. This relationship let RPP acknowledgement that, the cost which invest on marketing issue will proportional deduct the revenue from raw material (F5).

The effect of combination between IP1(On time sample delivery (%)) and IP5 (Labor Cost per production output (Baht/Kilogram)) on F5 have provide negative side, when both IP1 and IP5 increasing its own value. The most effect on F5 is IP5. This case, it is normal analysis

cause and effect for finished goods production and selling. The combination model of regression between IP1 and IP5 has similar result as the combination of IP4 and IP5. It given the negative site to F5, IP4 is main cause for IP5. IP5 is the parameter which, divided by output of products (kg). So the result is similar to IP4, but depend on the products output of each month that RPP can produce.

Refer to the multiple regression model F5 = 2693 - 85.3 IP4* + 326IL2*, IP4 given the negative side to F5, in contrast with IL2 (Bonus per salary (%)) provide the positive side to F5 when both increasing in its own value. This is mean, the revenue from raw material able to to increase by gain up of IL2. However, the IL2 will effect to interest rate of RPP. So the IL2, control schematic has to consider with interest expense together.

When the combination between IP4 and IL4 (Welfare per salary (%)) took place IL2, IL4 was given the negative side to F5 at some degree. However, the increasing of IL4 has given maximum positive to F5 at 15.8 Unit. Welfare able to improve quality of employee working life, its made morality of employee come better. IP4 and IL4 regression model on F5, has similar trend as the combination of IP5 and IL4. IP5 is derivative of IL4, where production output was accounted for.

See the IP5 and IL3 (Over time per salary (%)) combination multiple regression model, when the value of IP5 and IL3 increasing, IP5 deduct on F5 value while IL3 enhancing F5 value. So that, the over time able to increasing, revenue from raw material as usual. However, overtime working has limitation at maximum IL3 value at 1 (100%). This result is going as the similar way as polynomial model plot between IP1 and IL3, where IL3 is complete at maximum consideration 100%. Overtime is a major policy that RPP management command to production employee to do. So this relationship, the only IP5, can do only parameter to control to get the maximum revenue from raw material.

CONCLUSION AND RECOMMENDATION

Refer to results and discussion, this thesis work able to support for the two major problems. First, the R&D and production department able to effort the RPP on new revenue from new customer; effect of C1 (New customer per total customers (%) on F3 (EBIT per number of R&D staffs (Baht/head)) which clearly founded under multiple regression method. Where (IP5 Labor Cost per production output (Baht/Kilogram)) is supportive parameter. model 6-1, is the relationship between C1 and F3, which C1 is mainly reflect to new customer, which intake from satisfaction of new product from R&D.

$$F3^* = 126 + 16.51C1^* - 39.4IP5^* \qquad (6\text{-}1)$$

New products from R&D derived to customer under C4 value (Successful order (Approved Art Work) per total order (%)). As results, C4 given revenue from raw material decrease at some degree. Due to a free sample to new customer or new order, it is absolutely deduct to F5 value (Revenue per raw material cost (Baht/Baht)).

$$F5^* = 1142 - 2.98C4^* + 0.425IP3^* \qquad (6\text{-}2)$$

$$F5^* = 2085 - 2.53C4^* - 35.9IP5^* \quad (6\text{-}3)$$

model 6-2 and 6-3, repents for relationship of new product to new customer by R&D (C4) on revenue per raw material cost (F5). Thus R&D can strongly effort RPP to get more new customer and enhance EBIT of RPP**.** Where F5 (revenue) is sub-unit of F3 (EBIT).

Second, the data which correct during fiscal year 2008 related to ISO 9000 version 2000 item 18, especially for innovation and learning focus let the RPP managements to concern on it. Innovation and learning perspective of RPP has shown that, it able to provide positive value to RPP firm. From polynomial regression model, it was found that innovation and learning parameter, which focus on over time working on work quality. During fiscal year 2008, 5% overtime can only provide on time delivery at maximum 99.2%. As a result, the over time is no need to apply for the employee.

This thesis work is carry out for the suitability monitoring and control parameter of information currently collected and capable to used in an organization based on balance scorecards frame work. Previously, the management focus only on one dimensional performance measurement, that is accounting system. Accounting system can only determine company profit or lost, but it does not inform the management level about internal process performance, customer relationship performance, and quality of work life performance. As a results from productivity and performance study, it was found that internal process perspective parameter (IP), customer perspective parameters (C), and innovation and learning (IL) perspective parameters able to enhance the RPP management on financial control (F). Furthermore the study of, it is also use as a general tool to motoring and control total plant operation, total quality policy, customer relationship management, and employee development. The out come of this work, states clearly for which parameters that managements of RPP are able to use to solve the company in further situation. Most of BSC parameters able to effort the performance of financial point of view especially for F1 (Interest per man-day cost (Baht/Baht)), F2 (Revenue per trial order (Baht/Baht)), F3 (EBIT per number of R&D staffs (Baht/head)) and F5 (Revenue per raw material cost (Baht/Baht)). Unfortunately, this thesis work is not find any relationship between IP, C, and IL on F4 (Revenues from new product per total revenue (%)).

Further information, the only study on simple regression from BSC parameter, the results from simple regression model does not provide sufficient data to the management of RPP. Additional study especially for polynomial regression given the RPP management able to view unseen result from polynomial model, as present in Figure 13, it is the relation ship between working overtime and results of on-time work. The result was answered the RPP management for the optimality of working. It was found that over time which no more than one hour is the maximum of RPP employee can release maximum productivity output. From multiple regressions, it was found the combination of each balance scorecards parameters effect on financial perspective. The combination of each parameters have dramatically shown side effect to financial perspective. The results from multiple regression model effort the RPP managements to firmly analyse the business situation based on mathematically analytic together with the management experience.

Finally, the firm foundation most wanted is income which is reflecting directly from EBIT. From this thesis work, it was found major relationship as summarized in Table 12. To increase EBIT or make more profit, the RPP management have to increase positive activity from Table 12. It is C1, C2, and IL2 to improve in EBIT. At the same time negative activity such IP4, IP5, IP6, IL3, and IL4 have to minimize. In some case the IP6 have to maintain based on production department to get maximum yield as much as possible. To keep the employee morality, event the RPP has negative activity such IL4, the management has to compensate at the optimum level to maintain and improve quality of working life of employee on track, and welfare is a face of company that represent to global.

Recommendation

This recommendation generates a strong evidence for compliance with Requirement 8 of ISO 9001:2000 (dealing with performance measurement, analysis and improvement) and Category 4 of the TQA (addressing the issues of performance measurement, analysis and knowledge management). The data especially for additional on fiscal year 2008, it is recommend to RPP to do continual collection to keep in data base for further knowledge management. The additional parameter for further study are ROI form R&D new products, Revenue per energy cost, satisfied customer index, customer repurchasing rate. Limitation of this thesis work, due to the time limitation some parameter such F4 (Revenues from new product per total revenue (%)) is not carried for interrelation between BSC parameter. If the data form RPP is more specific for only F4 and new products revenue it could found some relationship that how is a big effect from new product launching for new plastic application/products. The accounting system for RPP include R&D department in production department, so the core cost of R&D activities can not recognitions for this thesis work. To predict the results from regression model, maximum of 3 units forwarding is recommended.

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APPLICATION OF THE TACIT SIGNAL METHOD FOR PERFORMANCE MANAGEMENT IN PROJECT-BASED ACTION LEARNING TEAMS

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ABSTRACT

This paper presents an integrative infrastructure for performance management in innovation-oriented learning organizations. The integrative design embraces both the concepts of project-based action learning (PAL) - driven organizational learning and tacit signal based performance management.

The concept of organizational learning (OL) has raised attentions of researchers and practitioners for a long time, from different perspectives. The studies of OL include the ideas of "continuous improvement, competence acquisition, experimentation, and boundary spanning" (Argyris, 1999). Learning Organizations (LO) are places where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continuously learning how to learn together (Senge, 1990). The effectiveness of OL process and better performance management is critical performance driver for many organizations.

This paper first discusses the background of the tacit signal method and how it is applied in performance management, and then describes the PAL framework with tacit signal e-HRM system embedded. In the integrative infrastructure presented in this paper, the tacit signal based e-HRM system is embedded as the built-in performance management tool under a Project-based Action Learning driven organizational learning setting.

The effectiveness of the proposed integrative infrastructure is verified by empirically grounded real company case studies. Case studies, in the form of tacit signal based action learning projects, were carried out in eight different SMEs at Finland. Results obtained from the case studies are very promising, and shows the proposed system supports innovation and learning.

Keywords: Organization learning, Learning organization, performance management, innovation management

INTRODUCTION

The concept of organizational learning (OL) has raised attentions of researchers and practitioners for a long time, from different perspectives (Argyris and Schon, 1978; Revans, 1982; Senge, 1990; Pedler 1991; Lyles, 1992; Garvin, 1993; Tsang, 1997; Garratt, 1999). The studies of OL include the ideas of "continuous improvement, competence acquisition, experimentation, and boundary spanning" (Argyris, 1999). Learning Organizations (LO) are places where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continuously learning how to learn together (Senge, 1990). The organization learning is the process by which the organization applies various modes of learning to achieve sustained competitive advantage (Wang and Ahmed, 2003).

Since the effectiveness of OL process can be hindered by some unprecedented events and organizational changes, the role of better performance management becomes even more critical and important. The OL vehicle, Project Action Learning (PAL) framework of Law and Chuah (2004) was developed for performance improvement and competitiveness sustainability.

The OL vehicle, Project Action Learning (PAL) framework of Law and Chuah (2004) was developed for performance improvement and competitiveness sustainability. Performance Management is one of the key features and supporting pillars of PAL implementation. Meanwhile, it has been found that management style leadership are influencing organizational performance (Schlevogt, 2002). Human factors such as stress and its impact on work performance have also been addressed (Putkonen, 2009). To understand these intangible factors, tacit signal method has been proposed to be used as an intelligent analytical tool to understand the competency levels of human resources (Kesti, 2007), and the tacit signal based e-HRM system is proposed as a human resources performance management infrastructure in the PAL-driven OL framework.

This paper first discusses the tacit signal method theoretical background and how it is applied in performance management, and then describes the PAL framework with e-HRM system embedded by the tacit signal method. A practical performance-managed-PAL framework is expressed and proposed.

BACKGROUND

The tacit signal method

The tacit-signal-based e-HRM system (Kesti et al., 2008) has been found effective in improving organization performance (Kesti and Syväjärvi, 2009) by offering intelligent analysis and monitoring. With the detailed analysis of competencies of human resources, this system can be used for competencies developments at collective levels. Therefore, it is definitely suitable for performance management in learning organizations.

Tacit signals refer to individuals beliefs concerning the improvement needs of human competencies. The tacit signals rise from personal tacit knowledge (Kesti, 2007). Tacit

knowledge is experience-based knowledge that is difficult to document or describe by words (Nonaka and Takeuchi, 1995). Tacit knowledge is highly personal and therefore it is difficult to express. The tacit-signal-based e-HRM system introduced as a human resource information system (HRIS) (Kesti et al., 2008) has been found effective in improving organization performance (Kesti and Syväjärvi, 2009). Nonaka and Takeuchi (1995) point out that each employee is a knowledge worker having important tacit knowledge about the organization's operations and work. This individual tacit knowledge can be used for competencies developments at collective levels. In many cases the most important competencies are leadership, team culture and work process (Kesti and Syväjärvi, 2009).

Leadership competencies at collective level

In working units the tacit signals can be used as guiding opinions to help solving problems by fundamental concepts such as participative and effective leadership. "The leader who wants to create an emotionally intelligent team can start by helping the team raise its collective self awareness," (Goleman et al., 2008), while collective emotional intelligence seems to be characteristic for top performing teams (Wheelan, 2005). In team performance improvement it is essential to recognize that they may be working on situations that are dissonant (Goleman et al., 2008). Festinger (1957) concludes that people are motivated to reduce dissonance by changing or modifying their attitudes and behaviors.

One negative way to resolve the dissonance is to create defensive reasoning for not to do anything about it (Argyris, 2004). Senge (2006) describes the same phenomenon so that organization learns harmful defensive routines which prevent problem solving and organization learning; "Defensive routines are so diverse and so commonplace, they usually go unnoticed" (Senge, 2006). A team's success depends on its ability to face the problem and to overcome defence mechanisms that surround the problems (Argyris, 2004; Senge, 2006).

Self recognition and performance

Another important issue to understand and surpass in management and organization development is the knowing-doing gap (Pfeffer and Sutton, 2000). The nature of the organization development is so that employee participation in planning and implementation will create sustainable productivity growth were quality of working life is improved along with performance (Ramstad, 2009). Organizations should not try to implement other organizations best practices but rather find out their own best value practices (Pfeffer and Sutton, 2000). Employees have ideas for optimal performance improvement. Succeeding in implementing these ideas to practice will create positive feelings. At Losada and Heaphy (2004) research the team performance seems to correlate with members positive feelings against negative. Positive/negative feelings ratio (P/N) exceeding 2.9 (Losada line) will speed up the team performance. In high performance teams the members experience positive feelings five times more than negative. In those teams the individual gets as much attention as team itself. (Losada and Heaphy, 2004).

Building a learning organization

Practical improvement actions at collective level are needed for development a learning organization. These actions need to come from the knowledge of the team members while optimal improvement actions arise from the team needs and situation (Hunt, 1992). Team members have both, the tacit and explicit knowledge. Tacit knowledge can be converted to explicit knowledge and can facilitate social interactions among the team members (Nonaka and Takeuchi, 1995; Nonaka and Konno, 1998). Social constructive communication produces dialogue, discussion and observation that speeds up the knowledge creation process and activates team learning.

Monitoring and control of team competencies

Kaplan and Norton have pointed out that there has been lacking good company specific measures for the learning and growth perspective. They note that absence of specific measures indicates that the company is not linking its strategic objectives to activities for re-skilling employees, supplying information, and aligning individuals, teams and organizational units to the company's strategy and objectives (Kaplan and Norton, 1996). Tacit Signals measurement and improvement actions follow-up makes it possible to measure organization learning and growth.

A holistic tool for organizational performance

To overcome above mentioned organization development obstacles the effective methods and proper tools are needed. It seems that organization can convert these problems in to great possibilities by developing every working unit's performance so that the whole organization productivity will improve (Welch and Welch, 2005; Kesti and Syvajärvi, 2009). Tacit signal development process with effective IC-tools have been proven to be effective in organizations continuous development (Kesti and Syväjärvi, 2009). With the help of systematic development process the leaders can learn to solve team problems and challenges in a constructive way and team members learn that problems can be turned to possibilities.

TACIT SIGNAL MEASURING AND ANALYZING PRINCIPLE

Research indicates that measured level of core competencies (leadership and culture) correlate with organization business performance (Kesti and Syväjärvi 2009). Improving competencies foresee better business performance. (Kesti and Syväjärvi 2009; 2010). Employee competencies, engagement and knowledge have great affect on internal process and business performance and they are critical in the organizational development process (Chareonsuk and Chansa-ngavej, 2009).

Tacit signal eHRM aims at providing clear overall view of the entire human resource competencies of the company. The competencies of a company in relation to its goals can be presented clearly and reliably for the resources allocation and relating decision making at management level.

The working principle of e-Tacit Signal System

Measuring the competencies can be done by survey studies relating to their improvement needs. Each group member has personal performance potential for doing the issues described by the competence attributes. Each person gives their personal feeling on the amount of efforts should be input or level of advancement should be made on a particular competence attribute. Personal competence is then calculated from potential (P) and the direction of the development need (Figure 1).

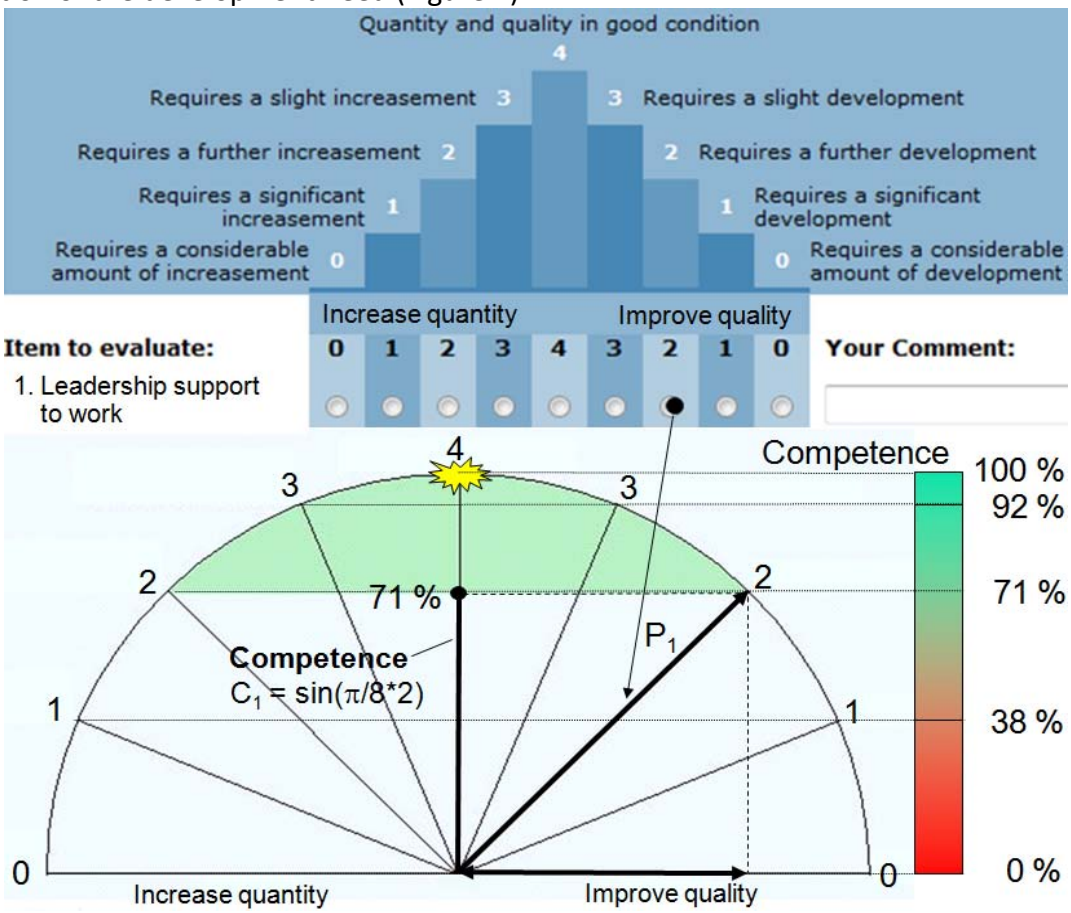
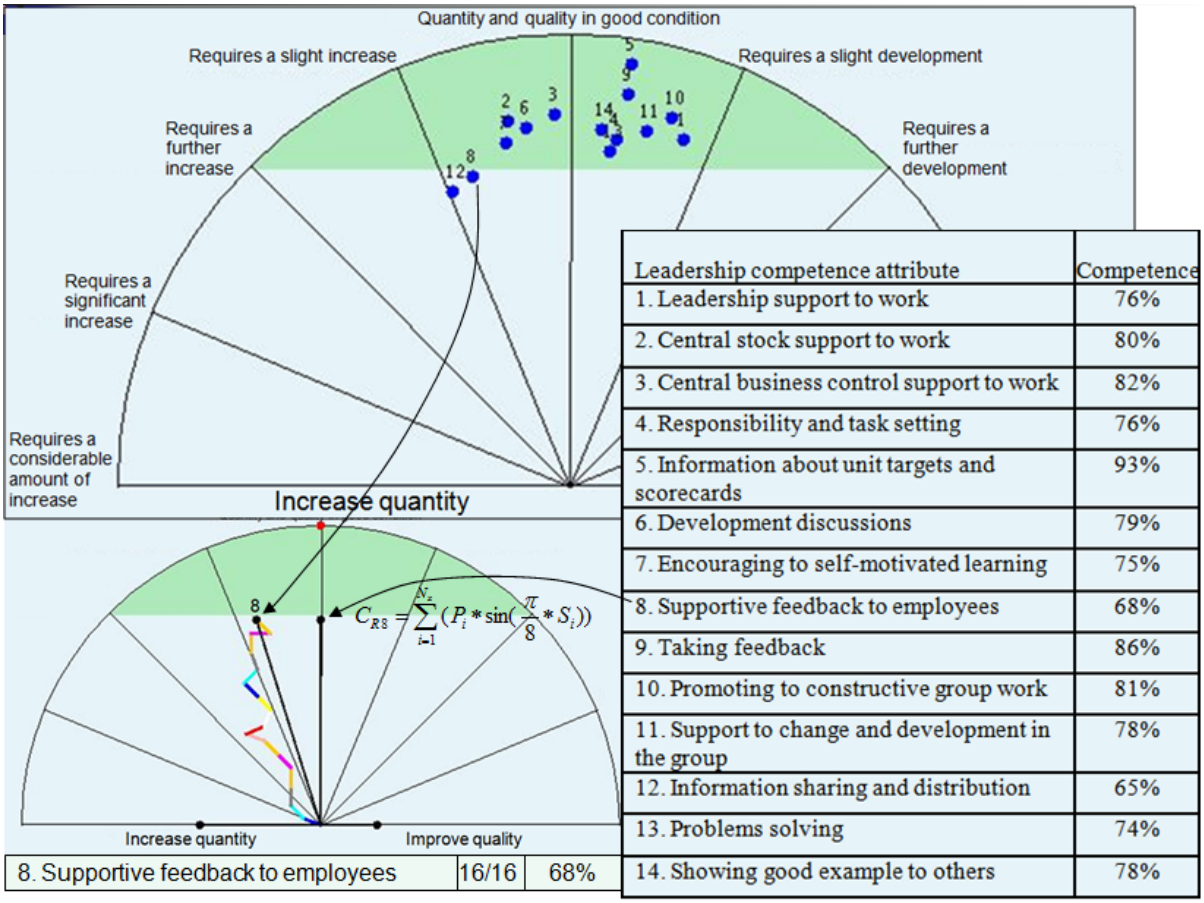


Figure 1: Personal competence measurement principle, where competence attribute is shown using vector that direction is according the person's opinion.

Each member's individual competence is measured based on the intensity of development needs (Value, S) on the particular competencies. The development value S of competency is represented by the angular vectors shown on the semicircular scale. Individual competency values would be then stored into the corresponding database.



Leadership competence attribute	Competence
1. Leadership support to work	76%
2. Central stock support to work	80%
3. Central business control support to work	82%
4. Responsibility and task setting	76%
5. Information about unit targets and scorecards	93%
6. Development discussions	79%
7. Encouraging to self-motivated learning	75%
8. Supportive feedback to employees	68%
9. Taking feedback	86%
10. Promoting to constructive group work	81%
11. Support to change and development in the group	78%
12. Information sharing and distribution	65%
13. Problems solving	74%
14. Showing good example to others	78%

Figure 2: Analyzing group collective competencies at semicircular scale (Kesti and Syväjärvi, 2010).

The tacit signal values are visualized by analyzer that supports both ASP- and Java-technology and the handling of html-files. Figure 2 shows the competence values presented with the aid of analyzer.

Development need values at collective level are then calculated by taking the average value of the summed up values of the entire group being measured. The mathematical formula for balanced total competence for the entire group is illustrated in Eq.1 as follows (Kesti, 2002).

$$C_{R1} = \sum_{i=1}^{N_x} (P_i * \sin(\frac{\pi}{8} * S_i)) = \sum_{i=1}^{N_x} (P_i * \sin(\alpha)) \qquad \text{(Eq. 1)}$$

where
C = Group competence
P = Group member competence potential
Si = tacit signal guiding opinion from the inquiry, Si ∈ (0 … 8)
π/8 = angle interval at the semicircle opinion scale
α = angle of the potential segment of a line ($0 \leq \alpha \leq \pi$)
Nx = number of group member answers

Tacit signal method is based on inquiry where individual gives development need for each competence attribute. Competence consist attributes of human performance drivers that are typical for high performance team emotional intelligence (see Goleman et al., 2008). Measurement can be seen as personal feeling of situation in pressure-performance curve.

This inverted U-curve is originally invented by Yerkes and Dodson (Yerkes and Dodson, 1908). Goleman (2007) points out that stressed people become defensive and too high stress hormone levels causes mistakes and disables learning new things.

PROJECT BASED LEARNING AS ORGANIZATIONAL LEARNING VEHICLE

Organization project action learning (PAL) framework is comprehensive for organizational learning and development (Law & Chuah, 2004). Organization systematic development can be seen as multiplied and repeated development projects for improving organization intangible assets. Built on the theoretical foundations of action learning (Revans, 1982), PAL is a practical OL solution that uses goals and project setting to drive both individual as well as team learning in a systematic way. Earlier research of Law & Chuah (2004) has identified that four supporting pillars, namely as Policy and Strategy, OL Facilitation, Technology and Resources, and Performance Management, are crucial to the PAL implementation success.

Integration of tacit signal HR system and PAL framework

Performance management concerns essential components of business excellence such as management, team factors and processes. There have been a number of frameworks developed striking for optimization of performance management, PAL is one of these, an effective measuring and monitoring tool for organizational performance is thus needed.

In this project, a comprehensive HR performance management system is development by integrating the tacit signal method into a development framework based on organizational learning concept (PAL).

The proposed tacit signal e-HRM system is anticipated to produce valid data for decision making, strategic planning, resource allocation and learning facilitation. Pfeffer and Sutton (2000) point out that it is essential to overcome the knowing doing gap that usually prevent learning. Performance improving learning comes from doing the right actions based on the existing knowledge of the organization (Pfeffer and Sutton, 2000). Therefore, knowing the current situation is the foremost task for further implementation of optimal improvement actions.

The **PAL-tacit signal performance** (PAL-TSP) **system** is applied throughout the entire PAL process, it facilitates, collects, measures, analyzes tacit competencies for the performance management (Figure 3).

The PAL framework embedded with e-tacit signal system facilitates the human resources performance goal setting, measuring and monitoring. The performance goals are well defined and agreed and thus can be further measured according to the human related performance quantifiable metrics like absence, turnover rate and competencies. Competencies are specific and are measured by tacit signals at different pre-set milestones throughout the PAL life cycle. Research studies indicate that tacit signal competencies can present organization performance in a systematic and quantifiable manner (Kesti and Syväjärvi, 2009; 2010). Some intangible indicators such as learning goals at collective levels can be measured with reference to the predefined performance indicators.

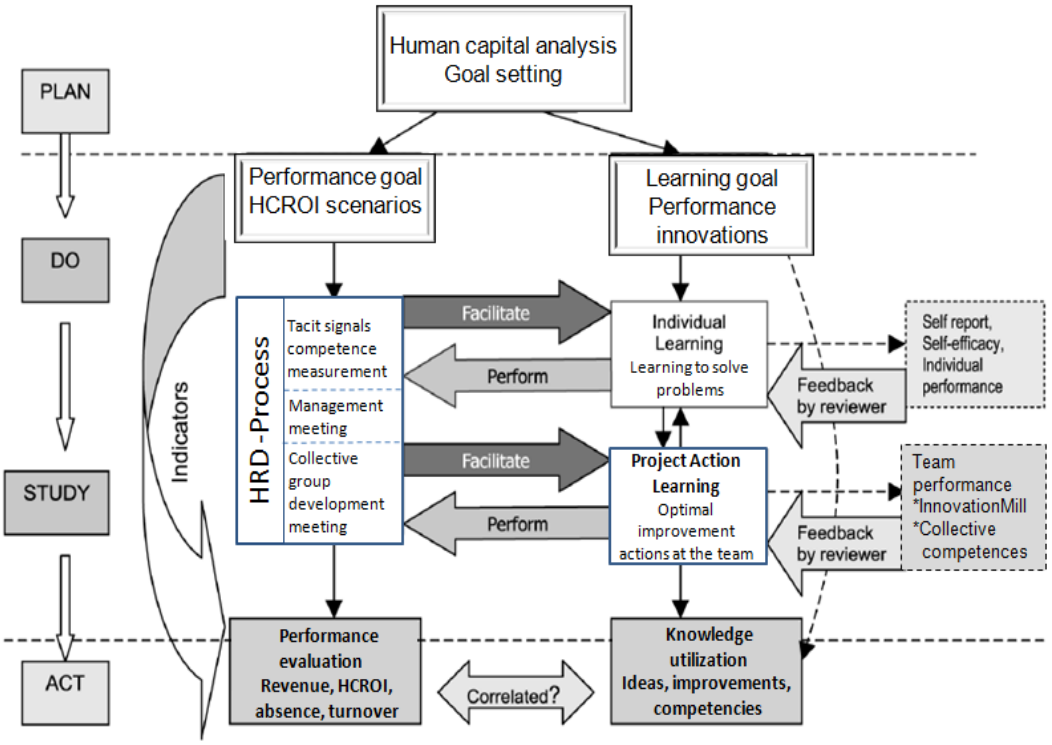


Figure3: The PAL-tacit signal performance (PAL-TSP) framework.

The PAL-tacit signal performance (PAL-TSP) framework is a comprehensive organization sustainable performance management framework with systematic and effective project action learning development process. Human capital can be seen as the capacity of an organization to use resources and human capabilities in order to achieve their organizational goals (Ulrich and Brockbank, 2005; Gratton, 2004). Human capital performance is analysed and the goals are set at strategic level. These goal settings form sustainable development goals that are based on human capital development strategies for three to five years time span. The strategic scenarios illustrate how the human capital development pay pack in better business performance (HCROI = Human capital return on investment).

Systematic and effective strategy is the key for human capital performance improvement. In the proposed framework, human resource development goals are developed based on the tacit signals analysis at team level, which provide the baseline for development process. This HRD development process aims at activating the individual learning as well as at team level learning.

ILLUSTRATIVE CASES OF TACIT SIGNAL E-HRM SYSTEM

To testify the effectiveness of the proposed system, case studies have been carried out at eight different SMEs at Finland. Study supports that tacit signal projects produce useful innovations at every company. Systematic development method with IC-tools speeds up learning process at teams. Teams have succeeded to carry out average three practical improvements in ten months follow-up time. These actions were collectively chosen and implemented in each group.

Table 1: Case study in 8 SME companies on tacit signal implementation.

Size	Teams	Business branch	No. of Ideas	Going on	Carried out	Ideas per team
50	6	Chemical industry	61	30	11	17,0
10	1	Trade and services	23	5	4	32,0
60	8	Tourist industry	63	29	28	15,0
54	5	Production industry (consumer)	53	10	19	16,4
46	3	IC industry	56	12	5	24,3
63	4	Production industry (B2B)	23	7	14	11,0
130	5	Rehabilitator	80	28	14	24,4
152	5	Hospital	56	29	13	19,6
565	**37**	**Total**	**415**	**150**	**108**	**18,2**

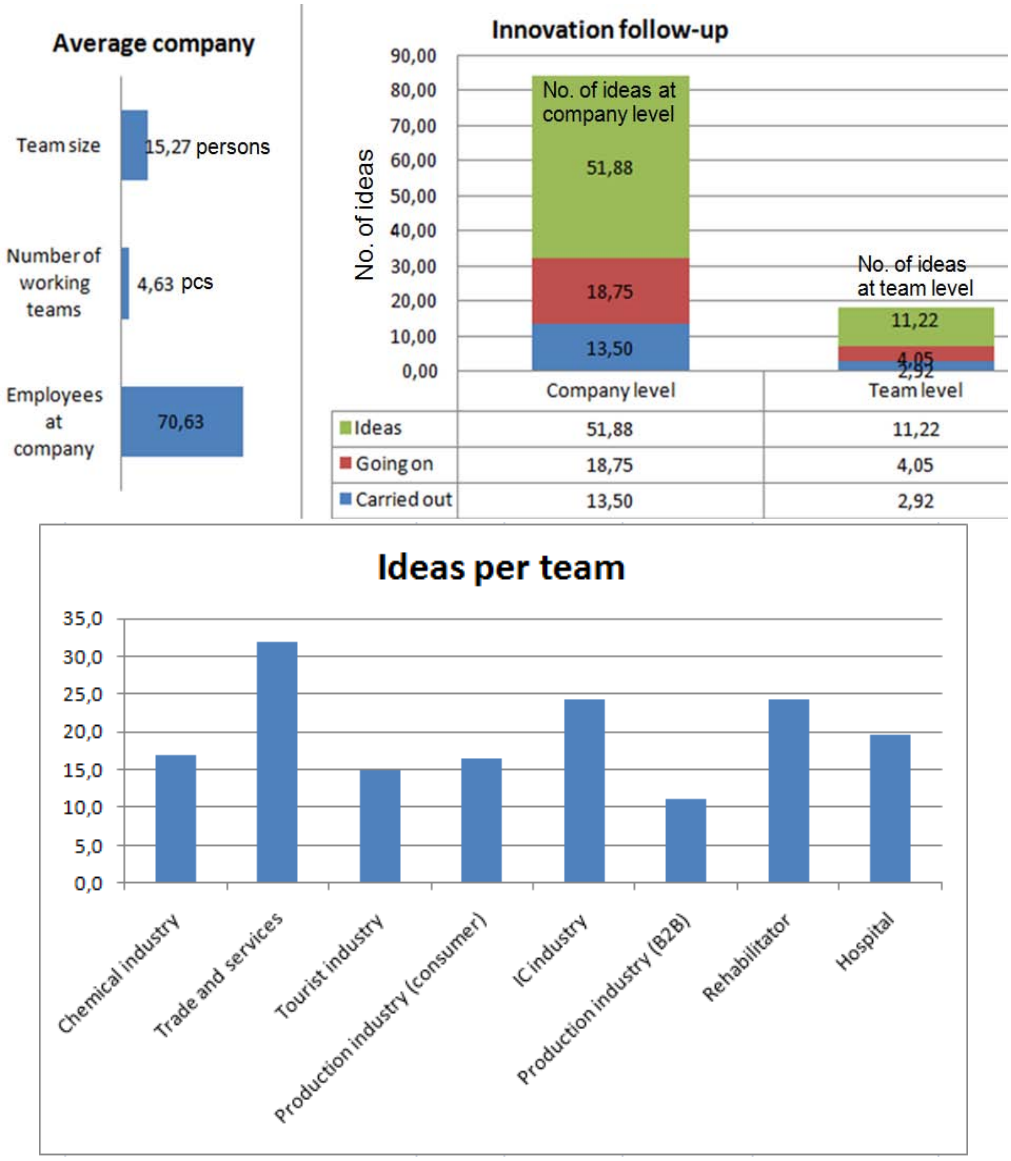


Figure 4: Summary of case studies illustrating how the proposed system supports learning and innovation.

In effective team the members must be able to adapt, learn and perform as a team (Law and Chuah, 2004). PAL development project reinforces the team level innovativeness to solve problems and improve operation proactively. Management needs balancing feedback to be able to implement strategy optimally (Senge, 2006). With the proposed e-HRM system better decisions can be made for optimal improvements. These actions, better understanding and decision making, are most optimal and contingent to the team performance excellence (Hunt, 1992).

CONCLUSION REMARKS

This paper presents an integrative infrastructure developed for effective performance management in innovation-oriented learning organizations. The integrative design embraces both the concepts of project-based action learning (PAL) - driven organizational learning and tacit signal based performance management. The effectiveness of the proposed integrative infrastructure is verified by empirically grounded real company case studies. Case studies, in the form of tacit signal based action learning projects, were carried out in eight different SMEs at Finland.

Results obtained from the case studies are very promising, and shows the proposed system supports innovation and learning. Teams are shown to have significant improvements in ten months. It seems evident that organizations can utilize their tacit knowledge better by implementing systematic and effective development process. It is essential that organization learning is properly managed so that the development is part of the organization sustainable performance improvement.

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G2 – Sustainability

G2.1 **Data warehouses for sustainable supply chain management**
Raúl León

G2.2 **Economic impact of moisture in wood-based bio-fuels**
Jouko Arvola

G2.3 **Environmentally innovation in the fuel sector: The role of biofuel from Algae**
Prof. Giovanni Lagioia

G2.4 **Green supply chain management with lingistic preferences and incomplee information**
Ming-Lang Tseng

DATA WAREHOUSES FOR SUSTAINABLE SUPPLY CHAIN MANAGEMENT

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ABSTRACT

This paper presents a reference architecture for information integration in sustainable supply chain management. This architecture aims to provide an integrated information infrastructure across a supply chain. It is intended to provide support to the interchange of information related to the socially responsible management of corporations by coordinating and communicating the information stored in the different information systems of companies across a supply chain. The presented reference architecture has been designed as an improvement and application of data warehousing technologies to the field of sustainable management of supply chains. It contributes to the research on the development of information and communication technologies for the integration of Corporate Social Responsibility in organisations.

Keywords: Corporate Social Responsibility (CSR), Sustainable Supply Chain Management (SSCM), Data Warehouses (DW), Interoperability.

INTRODUCTION

The concept of corporate social responsibility (CSR) is increasingly present in the business and social environment. CSR entails the adoption by organisations of a very wide range of polices and compromises covering social, environmental and economic dimensions and their application over the whole organisation's influence area.

There are many expected benefits from a socially responsible management (Moneva et. al, 2007). Organisations adopting the CSR model are expected to improve their processes and their relationships with their stakeholders in a manner that they would increase their shareholder's value and at the same time they would fulfil all their responsibilities and commitments towards society and other stakeholders (Husted and Salazar, 2006). Therefore, the economic, social and environmental benefits achieved when adopting socially responsible behaviours go beyond the boundaries of organisations themselves and involve wider communities (Ciliberti et. al, 2008).

In the same manner than CSR benefits exceed the boundaries of organisations, the requirements for its effective adoption also entail organisations managing external aspects,

so that companies need all firms in their own supply chain to act in a socially responsible way.

Sustainable supply chain management (SSCM) can be defined as the management of supply chains where all the tree dimensions of sustainability, which are the economic, the environmental and the social ones, are taken in account in planning and management processes (Seuring and Müller, 2008). Special effort should be paid when supply chains include small upstream producers that work in developing countries, since the responsibility for their well-being and performance should also be assumed.

This paper aims to contribute in the research on sustainable supply chain management by providing a framework to integrate the information stored by the different companies across a company's supply chain. To this end, a reference architecture for information integration is proposed. This architecture is based on sustainable supply chain management requirements defined in different standards and norms, and has been designed upon data warehousing technologies. The rest of this paper is structured as follows. After this introduction, Theoretical Background section briefly reviews literature on sustainable supply chain management and data warehouses. Then it is presented reference architecture for CSR information interchange across supply chains and the methodology used for its development. Finally, future research and main conclusions are summarised.

THEORETICAL BACKGROUND

Sustainable Supply chain Management

According to CSR principles, companies adopting CSR should hold themselves accountable for the social and environmental impacts arising across their supply chain, and are compelled to integrate ecological and social aspects into their decisions and actions across their supply chains (Ciliberti et al., 2008). Organisations are not only responsible for the actions they do and the impacts those actions cause. They are also responsible for the actions of their suppliers and subcontractors (Neef, 2004).

Furthermore, as claimed by the Department of Trade and Industry "CSR is likely to become an increasingly important business issue for many SMEs in future. This is partly because of the increasing take-up of ethical codes of practice by their large customers, which is creating a pressure for demonstrably responsible behaviour back down the supply chain" (DTI, 2002). It is expected therefore large companies will stimulate the social responsible behaviour across their supply chain.

Sustainable supply chain management is defined by Seuring and Müller (2008) as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e., economic, environmental and social, into account which are derived from customer and stakeholder requirements". In this sense, the sustainable management of supply chain involves organisations efforts to further social and environmental goals in their supply chain.

Managing supply chains in according to sustainability principles brings many challenges to traditional supply chain management, which was mainly focused on efficiency, information sharing, and joint planning. (Foran et. al, 2005). In this regard, the sustainable management of supply chain involves transferring supply chain's partners socially responsible behaviours, and it helps corporate managers to "manage the environmental risks posed by their supply chain" (Gascoigne, 2002). To this end, companies can use the following management tools (Martela, 2005): a) establishing written requirements; b) monitoring supplier performance; and c) contributing to supplier's awareness building and training.

Establishing supplier requirements entails defining guidelines and requirements to establish social and environmental performance for the organisation's suppliers. It is usually the first step in managing the organisation's supply chain responsibility (Jamison and Murdoch, 2004), and suppliers are usually required to comply with law and some CSR standards.

Supplier performance monitoring consists of activities carried out to keep a close watch over suppliers to check that the their behavior is consistent with established requirements (Ascoly et al. 2001). One of the key characteristics and requirements of monitoring is that it is a frequent or continuous process. Otherwise, it would be very difficult to detect variations in partners' behavior or circumstances. An effective supplier performance monitoring requires companies to devote important resources in training their employees, instructing their buyers and establishing appropriate measures in cases of violation of the code including accompanying measures, among others. Furthermore, they also need to upgrade their information systems to comply with the new requirements.

Finally, contributing to suppliers' awareness building and training pursues to communicate and raise the awareness of the targeted audiences to the company's philosophy and policy about corporate responsibility issues. The potential audiences that should be addressed by this tool include, but is not limited to, the own organisation, the management level of supplier and the supplier's workers. This tool requires long term relations with a significant level of trust that enables effective communication, education and training of the different parts (Martela, 2005).

These three tools can be combined to define sustainable supply chain management strategies that range form compliance with requirements and capacity building (Jamison and Murdoch, 2004). The compliance with requirements approach focuses more on the establishment of written requirements and the monitoring of supplier performance. The capacity building approach is rather focused on awareness building and training.

The implementation of the above mentioned strategies in supply chains increases the interdependence between companies. Interdependence refers to the extent to which organisations need to exchange information or material to accomplish their tasks (Thompson, 1967). The increased interdependence that arises when sustainable supply chain management strategies are implemented is closely related to information interchange and analysis. Therefore, sustainable supply chain management requires organisations in the supply chain to share more information, and to provide them with the necessary tools to manage and analyse the shared information. Greater interdependence between

organisations requires greater coordination/communication mechanisms to promote information sharing.

A reference architecture for information integration has the objective of developing an integrated information infrastructure that communicates and coordinates the different technological devices that generate, process, distribute and supply information (Chalmeta et, at., 2001). Literature provides a wide range of technologies and tools for information integration, each one with specific characteristics and functionalities. Regarding CSR information integration across supply chains, a reference architecture should solve traditional problems related to technical and semantic integration, but it also should provide the necessary analytic functionalities to evaluate the performance of organisations and the whole supply chain according to different criteria. In this regard, over the past decade, many organisations have made multidimensional modelling and data warehouses (DW) the foundation of their decision support infrastructures (Ariyachandra and Watson, 2010), due to their capacity of integrating and storing data from different sources, and the analytic functionalities they enable.

DATA WAREHOUSES AND MULTIDIMENSIONAL MODELLING

The data warehouse technology was initially introduced by Devlin and Murphy (1998). According to their initial proposal, a data warehouse is a read-only database specially designed to store historical data for operating, which offers integration tools for users to query and search what they need for decision supporting and analysing.

By using data warehouse technologies, data is extracted from data sources, transformed, and loaded into data stores. The data is then made available for end user access and decision support applications. It can be considered as a decision support data infrastructure that is used for multiple and varied decision support purposes (Ariyachandra and Watson, 2010).

Data warehouses are designed to storage loans of data that may be used to “fuel” different applications, including traditional querying and reporting tools, but also more sophisticated systems that can be classified within what is generally known as busines intelligence tools. Those include decision support systems (DSS), executive information systems (EIS), online analytical processing (OLAP), or data mining, among others (Gray and Watson, 1998). Data warehouses are also enable and promote some of current strategic initiatives such as customer relationship management (CRM), business performance management (BPM), and supply chain management, among others (Ariyachandra and Watson, 2010).

What differences a data warehouse from traditional relational databases is that a data warehouse is a specially prepared data repository that is used to support decision making in an efficient way (Gray and Watson, 1998), in opposite to relational databases, which are designed to be efficient in registering transactions, saving storage space and granting consistency of data. To that end, data warehouses are designed using what is known as multidimensional modelling, rather than using traditional normalised relational modelling.

Multidimensional modelling structures information into facts and dimensions. Facts represent atomic information elements in a multidimensional database (Hüsemann, 2000), and they are used to memorise measures about situations or events (Schneider, 2008). Dimensions are used to analyse facts, particularly through aggregation operations. By means of dimensions, a fact consisting on simply measures can be qualified according to a specific context. (Hüsemann, 2000). In summary, facts contain interesting measures of a business process, whereas dimensions represent the context for analysing facts.

The implementation of a DW increases information processing capacity (Galbraith, 1974). That capacity is closely linked to the architecture used to implement the data warehouse. Literature upholds that the extent of information interdependence between organisations determines the need for different levels of information processing capacity, which in turn determines the most appropriate data warehouse architecture (Ariyachandra and Watson, 2010). At company level, two main architectures are generally used: the Enterprise data warehouse (EDW) architecture (Inmon et. al, 2001) and the Data warehouse bus matrix (Kimball, 2002).

EDW was the first method used in the development of enterprise wide data warehouses. With this method, data warehouses are implemented by a top down process, and they are architected, designed and constructed in an iterative manner. In an EDW, the entire enterprise data warehouse is modelled, and then small slices of subject areas are chosen for construction. This approach provides two major advantages from an implementation perspective: a coordinated environment and a single point of control & development.

With the Data warehouse bus matrix architecture, data warehouses are implemented by a bottom up approach. With this approach a smaller enterprise data mart architecture is developed to provide a context and foundation for further development, which is built from a series of incremental, architected data marts.

Both architectures have evolve during past decades, but they remain the base for other architectures such us central data warehouses, that usually employ a hybrid approach to overcome some of the limitations of previous architectures, or federated data warehouses, that attempt to consolidate distributed data warehouses.

This research uses the Data warehouses bus matrix due to their capacity for architecting incremental data warehouses. While this method was initially designed to be used in single organisations with multiple business units, its principles can be adapted to be used un supply chains.

SSCM ARCHITECTURE

Literature provides a wide range of methodologies, models and tools for the integration of different DW with the aim of generating a federated data warehouse that can be queried as a whole. Those contributions are, however, focused on solving the problem of integrating different DW in order to provide as integrated information as possible.

That objective is not the main one pursued by this research. This paper mainly aims to define a DW global schema for CSR integration across supply chains. Therefore, the objective is to help companies to interchange the required information to manage their corporate social responsibility across their supply chain, but not to reach the maximum level of integration among the already existing information systems of the companies in a supply chain. By defining a standard bus interface for CSR management across the supply chain, separate data marts from different organisations can easily be plugged together to provide a global view of the whole supply chain, and a more effective sustainable supply chain management is possible.

The proposed reference architecture is based on the data warehouse bus matrix architecture proposed by Kimbal (2002), which has been adapted to fulfil the CSR information integration requirements for sustainable supply chain management. This architecture has been designed with a methodology that can be used by companies with specific requirements, and is intended to design a reference model to the integration of information across supply chains.

The reference architecture defines a set of critical interoperability CSR facts. Furthermore, minimum facts' dimensions and dimensions granularities are defined, in a manner that a SSCM data warehouse bus matrix is defined. Finally, it also provides guidelines on defining information interchange procedures, based on the use of queries that are propagated along the supply chains and data-marts that are increasingly filled by organisations in the supply chain according to petitioner needs. The SSCM architecture is presented in the same order that the methodology which has been used in its development.

Phase 1. Identifying critical interoperability facts.

The development of a supply chains data warehouse bus architecture begins with the identification of the business requirements for the different business process that need to be supported. In the context of the problem being addressed in this research, it is necessary to analyse the different processes involved in sustainable supply chain management. Those processes may vary significantly among different organisations. However, many researches have attempted to generalise the main elements that characterise supply chain CSR in al industries. Literature pay special attention to elements such us logistics, purchasing, procurement, employee training, philanthropy, environment, urban renewal, workplace diversity, health and safety, human rights or labour practices, among others (Carter and Jennings 2002a; Carter and Jennings 2002b; Poist, 1998)

The first phase of the methodology aims to make a careful determination of which facts will be interchanged among companies. Critical interoperability facts can be defined as the set of facts of special of special value for the interoperability among organisations. In the scope of CSR, critical interoperability facts are those related to the sustainable managements of economic, social and environmental aspects across value chain.

The amount of facts that should therefore be addressed in sustainable supply chain management may be considerably huge. The facts included in the SSCM architecture (Table 1) have been defined as a result of a deep analysis of different international norms and

standards such as Global Reporting Initiative (GRI) guidelines, ISO 9000, 14000, 26000 families, OSHAS 18000 and SA 8000, as well as specific tools and protocols. However, organisations involved should negotiate a set of critical interoperability facts that they should share in order to enable an efficient supply chain management. This initial set can be enhanced later, thanks the incremental development capacity of the bus matrix architecture.

Fact	Description
Analysed business unit	Number of business units that have been analysed according stabilised CSR polices
Complaints	Number and monetary value of received complaints
Donations and other community investments	Number and Monetary value of donations
Economic value generated	Monetary value generated by the organisation
Employee training	Total hours and monetary value of employee training
Energy consumption	Amount of energy consumed
Environmental damages	Number of environmental damages caused by the organisation
Environmental protection investments	Number and expenditures invested for environmental protection.
Financial assistance	Monetary value of financial assistance received by goverment
Gas emissions	Amount of gases emitted by the organisation
Human Rights violation	Number of human rights violation arisen from organisation activities.
Incidents of discrimination	Number and monetary value of incidents of discrimination happened within the organisation
Labour accidents	Number and monetary value of labour accidents suffered by staff
Legal actions	Number and monetary value of legal actions initiated by the organisation
Materials comsumption	Amount of materials consumed by the organisation
Non-compliances	Number and monetary value of non-compliances with regulations and voluntary codes
Payments	Monetary value of payments to suppliers
Social investments	Number and total expenditures invested for social purposes.
Staff	Number of people and total workforce employed by the organisation
Staff turnover	Number of employee turnover
Staff wage	Wage received by employees
Suppliers	Number of suppliers monitored
Tax payments	Monetary value of taxes paid to governments by the organisation
Waste	Waste generated by the organisation
Water consumption	Amount of water consumed by the organisation.
water discharge	Amount of water discharged by the organisation

Table 1: Critical interoperability facts for sustainable supply chain management.

Phase 2. Identification of critical dimensions

During the second phase, the dimensions that will be used for facts analysis are defined. The different criteria which are needed to conduct analysis along a dimension are introduced through members. Members of a dimension are generally organised in a hierarchy which is a conceptual representation of the hierarchies of their occurrences (Schneider, 2008).

Although the identification of critical dimensions and their members is closely linked to the CSR aspects selected in previous phase, there are two dimensions that should necessarily be included in the model due to their importance in CSR management. Those essential dimensions are Date and Location:

Date

Date dimension refers to the moment of the time when the fact is produced, and it dimension allows to analyse how facts evolve over time.

The minimum grain detail for Date dimension in CRS management is one year, which is the minimum period in which CSR reporting is desirable. However, more detailed grains such as quarter, month or even day should be used if they provide material information for the analysis of facts.

Members of date dimension should represent the different period of time that may be used for facts analysis. At least a member for each year should be created, but years may be hierarchal decomposed if more detailed grains are defined.

Location

Location dimension refers to the place where the facts occurs. The minimum grain detail for Location dimension is a Country, although more detailed grains such as state, region, city or even building should be used if the provide material information for the analysis of facts.

In the same way than member for Date dimension, at least a member for each country should be created. Other members representing more specific locations for more detailed grains.

Apart from Date and Location dimensions, that should be inevitably included, other dimensions that should be considered when defining the reference architecture for information interchange for sustainable supply chain management are:

Employee

Employee dimension refers to the employee that has caused of suffered a specific fact. This dimension should be designed contained employee attributes relevant to CSR management. Outside the original company, facts will rarely analyse at single employee detail, but they will necessarily analysed according employees attributes.

This dimension should include some interesting attributes to enable value added analysis. Those attributes are Birth date; Contract date; Gender; Origin; and Contract type.

Each organisation may define its own members for this dimension. Employee dimension's members should be codified in a way that any code is repeated across supply chain, so using a company prefix or attribute is necessary.

Energy source

An energy source dimension is needed for analysing energy consumption facts. Members of Energy source dimension represent the different sources of energy that can be used by organisation. A hierarchy containing at least electricity, com,

Gas

Members of gas dimension represent the different gases that should be traced across the supply chain. A hierarchy containing greenhouse gasses, ozone-depleting substances and other relevant air emissions members should be defined in Gas dimension

Water

Members of water dimension represent different water qualities and locations where the water came from or where the water went to.

Those are only some of the dimensions that should be considered. Other dimensions should be defined to include the necessary criteria to fully analyse other facts such as Non-compliances, Complaints, Labour accidents, or Material consumption. While many of these dimensions may only be applicable for a single fact, others could be associated to some of them. The association of facts and dimensions is defined in next phase of the methodology.

Phase 3. Definition of the data warehouse bus matrix

In this phase, dimensions are associated to facts. Those associations will determine the multidimensional granularity with which facts will be analysed, and therefore it also determines the minimum granularity with which facts should be registered and stored by the organisations in the supply chain.

The data warehouse bus matrix architecture is defined with the help of a matrix where facts and dimensions are linked. While the Date and Locale dimensions should be associated to all the facts, the other dimension may be associated to a reduced or wide set of facts depending on the specific analytic need. Table 2 shows an example of how to use a matrix to define the data warehouse bus matrix.

	Date	**Location**	**Dim. 3**	**Dim. 4**	**…**	**Dim. N-1**	**Dim. N**
Fact 1	X	X	X		…	X	
Fact 2	X	X		X	…	X	X
…	X	X	…	…	…	…	…
Fact M-1	X	X	X	X	…		X
Fact M	X	X		X	…	X	X

Table 2: Bus matrix for sustainable supply chain management. Adapted from Kimball (2002).

The selected critical sustainability facts and dimensions, and the data warehouse bus matrix serves as a reference framework to interchange information about organisations in the supply chain, but it also may provide companies within the supply chain with a rational approach to decomposing their data warehousing planning task. Using the CSR data warehouse bus matrix, organisations across a supply chain can share a common interface that allow them to interchange and aggregate date, and therefore to improve interoperation skills.

Phase 4. Adaptation of local information systems

The CSR DW global schema should be used by organisations across the supply chain for integrating their local information systems with the supply chain reference architecture. During this phase, organisations should face the integration of local information systems with the global schema of facts and dimensions.

At this point, it may occur that some organisations's information systems do not provide support for the management of specific sustainability facts, or that granularities of facts are not fully compatible with dimensions defined in the reference data warehouse bus matrix.

Organisations across supply chain should negotiate whether it is necessary to adapt local information systems for managing unsupported interoperability facts and dimensions, or if undetermined values are allowed. Whatever option is chosen, organisation should implement the necessary translations between the structures in which they store their local data, and the data structure defined in the supply chain data warehouse. This translation will strongly depend on the information system of any organisation, and there exist many procedures and tools that may facilitate considerably the process.

Phase 5. Information communication and aggregation

Once a set of companies have defined their own SSCM DW schema, and have adapted their local systems to manage the information according this schema, the next phase is related to information interchange.

The bus matrix architecture here presented provides a common reference for information interchange between companies across a supply chain. Figure 1 illustrates that by using a common set of critical interoperability factors and dimensions, organisations can easily share local data marts to build a supply chain data warehouse. However, the adequate interchange of data across supply chain requires a set of well defined rules that guarantee the adequate communication and aggregation of data across the supply chain

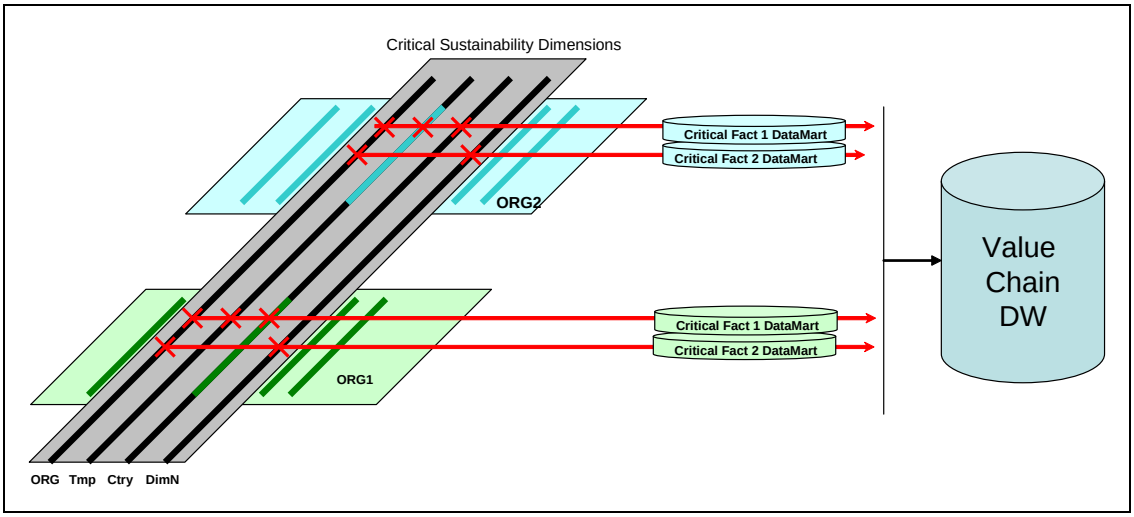

Figure 1: Data marts integration across supply chain by using a common data warehouse bus matrix.

Literature provides many alternatives to manage communication and aggregation of data between different organisations. This paper does not addresses low level implementation details, but presents some of the implementation guidelines that should be addressed.

As sustainable supply chain management does not need real time information integration, the architecture has been designed to integrate the information on demand. In this way, when an organisation needs to query supply chain information, it firstly compose the query in the same way than a local query. The query is formulated with a standard querying code, like SQL, but some meta-information is added. That meta-information includes the identification of the organisation starting the query, a query identification number, and a number indicating the levels the query must upstream in the supply chain. The query is therefore defined *Q={ OrganisationID, QueryID, NumLevels, SQLQuery}.*

The query *Q* is then submitted to direct suppliers of the organisation starting the query. The organisations receiving the query can act in two different forms depending on whether they are in the limit level stabilised in the initial query or not.

In the first case, the organisation answers the query with a response package *R* containing the requested data. Two additional dimensions are included in the returned data. One of them refers to the responding organisation identification. The other represents the level of the response, which is stabilised to value "1". The response package is defined as *R={QueryID, FactsSet, {DimensionsSet, OrganisationID, NumLevels}}*

In the second case, the organisation forwards the query to upper suppliers and waits for response. The forwarded query is modified as follows. The original value of CompanyID field is replaced with the identification of the organisation forwarding the query. The original value of CompanyID is added to the QueryID field. Finally, the number in NumLevels field is decreased by 1. Then, when the organisation receives the response packages, it aggregates all the responses, it subtracts the first company identification from the *QueryID* field in the responses, then it increases by 1 the values in the level dimension of responses, and finally it adds the data resulting from applying the query to its local data warehouse, with the value

of its identification in the dimension of responding organisation, and the value “1” in the level of response dimension. Once the response is completed, the responding organisations send the response to the querying organisation.

In this way, the query is propagated from the querying organisation to all organisations within the stabilised boundaries. All responses are increasingly integrated in a single data mart containing response data, which includes critical interoperability facts and the necessary dimensions for their analysis, but also the Organisation and Level dimensions to identify the facts across the supply chain.

It has to be noted that this process may introduce duplicated data when more than one path or circular relations, exist between querying organisation and any supplier within the boundaries of the query. Duplicated data can easily be identified in the response package because the same organisation identification code contains facts with more than one level or because exists duplicated facts. Those data should be carefully managed by querying organisation according its own needs.

CONCLUSIONS AND FURTHER WORK

This work contributes to research on extending corporate social responsibility management beyond organisation limits. To this end, this paper proposes a reference architecture designed to provide support to information integration and communication in supply chain management. The architecture explains the use of the data warehouse bus matrix as an interoperability standard for information interchange across the whole supply chain. It also includes some guidelines to define communication processes. Furthermore, the methodology is applied to build a standard information architecture for sustainable management of supply chains.

The sustainable supply chain management data warehouse architecture here presented need to be further tested and enhanced. While the proposed methodology may help organisations in a supply chain to define a common reference architecture for information integration, the developed reference architecture for sustainable management of supply chain is still in an early stage. More research is necessary in order to determine a commonly acceptable set of critical interoperability facts for sustainable supply chain management, and critical dimensions should also be further developed in order to grant the required analysis capabilities.

As a result of constructing a supply chain data warehouse, companies would be able to improve their sustainable supply chain management. On the one hand, because companies would be able to efficiently check supplier’s compliance with requirements. On the other hand, because the architecture may promote interoperability among clients and suppliers, and therefore along the whole supply chain. This situation may easily happen when a company’s suppliers understand CSR benefits and therefore start promoting CSR among their own suppliers

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ECONOMIC IMPACT OF MOISTURE IN WOOD-BASED BIO-FUELS

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ABSTRACT

The use of renewable biomass for energy production is increasing in Finland. Moisture content in bio-mass is commonly seen as a major challenge. This study analyses the economic impact of moisture in different parts of wood biomass supply chain by making calculations covering the entire supply chain. The methodology of this article includes literature review, interviews and economic calculations. The results of this study indicate that total costs for moisture content in Finland is annually some 50 M€ higher when using wood bio-mass with 45 w-% instead of 30 w-% by. Roughly half of this increase comes from transportation and another half from weakening burning efficiency. Properly organised air-drying is the simplest and cheapest measure to decrease transportation costs and improve combustion. Large power plants are typically capable of utilising air-dried wood bio-mass with moisture levels between 30-50 weight %.

Keywords: renewable energy, biomass, wood, moisture, economic calculations, supply chain.

INTRODUCTION

The global discussion on carbon dioxide emissions on the climate change has greatly influenced environmental considerations and legislation especially in Europe (e.g. Schmalensee et al.; 1998; Hansen et al., 2008). Using renewable energy instead of fossil energy is crucial when attempting to reduce green house gas emissions (United Nations, 1997; Hoffert et al 2002; IPCC, 2008). Renewable energy can be derived from different sources such as hydroelectric power, wind, photovoltaics and biomass (e.g. Rosillo-Calle et al., 2007; O'Keefe et al., 2010). Worldwide electricity production in 2009 was 66 % from fossil fuels, 26 % from renewable sources, 8 % from nuclear power. Capacity increase during 2008-2009 originated: 53 % from fossil fuels and 47 % from renewable. (REN21, 2010).

Biomass can be used to produce bio-energy from renewable sources. Biomass is an organic material produced initially by photosynthesis. Biomass may include plant materials, agricultural residues i.e. animal manure, crop-wastes and any other material made directly or as a by-product during biomass processing. Bio-energy contributes 10-15 % of primary worldwide energy production, however, there are vast regional differences in the availability. (Kaltschmitt et al, 2002; Berndes et al., 2003; Parikka, 2004).

Finland has committed to increase the use of renewable energy to 38 % of total end-user energy consumption (Finnish Government, 2008). In Finland, the wood-based primary energy in 2005 was 76 TWh, including wood chips 6 TWh, small scale use of wood e.g. fireplaces 13 TWh, black liquour in pulp & paper industry 37 TWh, and industrial leftovers 20 TWh. The national goal for using wood-based biomass by 2020 includes increasing the use of wood chips to 25 TWh, bio-fuels for traffic to 7 TWh, wood pellets to 2 TWh (Pekkarinen, 2010).

The moisture of wood has an impact on both, its burning and transportation (e.g. McKendry, 2002; Demirbas, 2004; Demirbas, 2005; Fagernäs et al., 2010). Consequently, it is vital to consider where and how wood is dried (e.g. Hillebrand, 2010; Röser et al., 2010). There are different moisture measuring techniques available, including both on-line and sample analyses (Järvinen et al., 2007; Korpilahti and Melkas, 2010)

This study analyses the economic impact of moisture in different parts of wood biomass supply chain. This study makes a wide analysis on the significance of moisture for using wood-based fuels in Finland, founding on the national goals for increasing the use of wood chips. The calculations cover the entire supply chain, including collecting the wood, drying, transportation and combustion process. The above can be condensed into the following research questions:

RQ 1 What is the supply chain required for harvesting, collecting and transporting wood-based bio-mass?

RQ 2 What is the economic significance of moisture in different parts of the wood biomass supply chain?

RESEARCH METHOD / PROCESS

The purpose of this study was to analyse the economic impact of moisture in wood-based bio-fuels in Finland. Figure 1 illustrates the research process for this study.

Figure 1: Research process.

First a literature review was conducted to obtain adequate understanding over using wood-based bio-fuels to meet the national targets set for renewable energy. In addition, the physical significance of moisture for combustion was clarified.

Second, 10 expert interviews were conducted to clarify technical and practical details concerning the combustion process in power plants capable of using wood-based bio-fuels and sourcing of bio-energy. The interviewees were experienced bio-energy experts covering the studied topic in a versatile manner, including all the phases of the bio-fuel supply chain .

Third, the interviews were thoroughly analysed in order to obtain solid basis for economic calculations.

Finally, economic calculations were conducted to understand the impact of moisture in wood-based bio-fuels in Finland. The purpose was to clarify the magnitude of the impact, rather than to give very detailed exact figures suitable for all cases. The calculations cover the entire supply chain, including collecting the wood, drying, transportation and burning process. However, this study does not cover all the details of boiler house efficiency. Also, potential investments are excluded in this study.

RESULTS

Supply chain for wood-based biomass

This study indicates that the moisture in wood-based bio-mass ought to be assessed throughout supply chain. The supply chain typically consists of 1) harvesting, 2) local movement of wood, 3) local storing & drying of wood, 4) chipping, 5) transporting woodchips to the point of use, 6) optional thermal drying, and 7) burning.

Harvested wood biomass may contain of collecting branches and stubs left after ordinary logging. However, this is not enough to meet the wood biomass needs, and may include separate thinning of woods. Thinning of woods for the purpose of collecting bio-mass improves the wood growth as a positive side-effect. Moisture content during harvesting is always high and cannot be influenced. Consequently measuring the moisture content during harvesting is not feasible.

Harvested wood needs to be collected to small piles thus requiring to be *moved locally*. During local movements, measuring the moisture content is not feasible.

Local storing and drying of wood is an essential low-cost step in reducing the wood moisture content. Collected wood is transported and stored in larger piles and air dried for at least three summer months or alternatively over a year. These larger piles locate in places accessible by larger vehicles for the purpose of later transport to a power plant. The large piles are covered by a tarpaulin to enable better air drying. Also, proper air ventilation underneath the pile needs to be assured. The pile is constructed so that rain water runs of the pile. The purpose of this phase is to reduce the moisture content to a level that the wood can be used as fuel. However, measurement of moisture is not typically organised as

the number of piles to be measured is extensive. The benefits of measurements are not seen to exceed the costs. Should the air drying be conducted correctly the moisture level is expected to be acceptable.

Chipping of wood is organised at the site for local storing and drying. Wood chips are loaded directly to trucks by the chipping machine. The moisture content of wood chips is an important parameter for burning process. In addition, excessive moisture content increases transportation costs unnecessary when water is transported. Moisture content is, however, typically not measured during chipping.

Wood chips are typically *transported* by trucks that have weight-based maximum load limitations, up to 38 tonnes. The trucks are 100-140 m^3 in volume. The moisture content has a significant impact on transport costs.

Wood bio-mass may be *dried thermally* after transportation, if cheap excess energy is available. This type of drying is optimally timed to occur during summers when excess energy is available from industrial processes. During winters, this excess energy is more sensible to be used for heating local houses. Thermal drying is, however, normally not conducted as the burning processes have typically been optimised to use wood bio-mass with moderate moisture content.

Burning processes have been typically optimised to utilise wood bio-mass with moisture content of 35-45 %. Moisture content is typically controlled by analysing samples taken from arriving wood chip loads. Moisture analysis takes some twelve hours, making the feedback mechanism slow from the perspective of burning processes. However, instant online measuring methods are currently under development.

Analysis of the economic impact of moisture

Fuel value for wood can be calculated by following equation (1) (Alakangas, 2000; Kaltschmitt et al., 2002):

$$LHV_A = LHV_D * (1-M) - \Delta H_{vap} * M \qquad (1)$$

where,

- ΔH_{vap} is the enthalpy of vaporisation = 2.441 MJ/kg
- LHV is the lower heating value
- LHV_A is the lower heating value on arrival
- LHV_D is the lower heating value for dry wood
- M is the moisture content on arrival.

Coal and hydrogen are the components of wood that burn in practise. When hydrogen burns, water is formed, requiring energy for vaporisation resulting in weaker total efficiency in a similar manner as the moisture absorbed in the input wood. According Oulu Energy, LHV_D = 19.4 MJ/kg is a typical value. This value includes this phenomenon and is used in the calculations.

Table 1 summarises the influence of moisture in real fuel value of wood. The values in Table 1 have been calculated as described above using equation (1). When moisture content is 25 w-%, the wood is considered well dried.

Table 1: influence of moisture on fuel value.

Moisture w-%	LHV_A MJ/kg
25	13.9
30	12.8
35	11.8
40	10.7
45	9.6
50	8.5

Table 2 illustrates the influence of moisture on the number of required truck loads.
Table 2 estimates how many truck loads of wood chips are required to meet the national energy production goal of 25 000 GWh/a, set for wood bio-mass. The calculations acknowledge the fuel values (LHV_A) for wood bio-mass with different moisture contents as given in Table 1. The calculations assume a truck load to be 35 tonnes in weight. Additional wood % means the amount of additional dry wood required to compensate for the negative impact of moisture. Additional truck loads is the additional loads required to transport the additional wood. The required number of truck loads is calculated by using equation (2).

Truck loads = (25 000 GWh / (LHV_A/3.6 MJ/MWh)) / 35 tonnes (2)

Table 2: influence of moisture on the number of required truck loads.

Moisture w-%	Additional wood %	Truck loads #	Additional truck loads %
25	0	184 467	0
30	1	200 147	8
35	3	218 740	19
40	5	241 141	31
45	7	268 653	46
50	10	303 252	64

Table 3 illustrates the additional annual transportation costs to meet the national energy production goal caused by increased moisture content. Typical compensation received by a truck company 2 €/km for a 35 tonne truck (Oulu Energy, 2011; Hakeyhtymä Kankaanmäki, 2011). It is assumed that an average transportation distance is 80 km, resulting in a truck load to cost 2 * 80 km * 2 €/km = 320 €.

Table 3 also shows the cost of additional raw material required to compensate for the moisture in order to meet the national energy production goals. The calculations are based on raw material price level of 20 €/MWh. The additional cost for raw material can be calculated using equation (3).

Additional cost = National goal / LHV_A * Additional wood % * Price level (3)
where,
Additional cost Additional cost for raw material

National goal	25 000 GWh
LHV_A	The lower heating value on arrival (fuel value)
Additional wood %	Additional dry wood required (from Table 2)
Price level	20 €/MWh.

Table 3: Additional annual transportation costs & additional cost for raw materials.

Moisture w-%	Additional transportation cost M€	Additional cost for raw material M€	Total additional cost M€
25	0	0	0
30	5	6	11
35	11	14	25
40	18	23	41
45	27	34	61
50	38	48	86

In reality, moisture content ranges between 30 – 45 weight-%. Table 3 shows that the total additional costs for moisture content 45 w-% exceed those for 30 w-% by 50 M€. This 50 M€ is the biggest theoretical impact of moisture in Finland. The market value for the national goal for 25 000 GWh is 500 M€, when using the market price of 20 €/MWh for wood bio-mass. The calculations thus show how the significance of moisture is only 10 % of the market value of wood bio-mass, opposed to a common understanding.

Raw material moisture content has an impact on the burning process, thus measuring of moisture is essential for optimising the process. Developing measuring techniques to enable real time monitoring of moisture levels would be advantageous. The supply chain has a number of involved actors. The wood moisture content has significance on pricing of raw materials among the actors.

CONCLUSIONS

As a part of European strive towards increasing the use of renewable energy, Finland has committed to increase the use of wood bio-mass. The moisture of wood has a significant impact on both, its burning and transportation. This study analyses the economic impact of moisture in different parts of wood biomass supply chain by making calculations covering the entire supply chain, including collecting the wood, drying, transportation and combustion process.

This study shows that wood bio-mass supply chain typically consists of 1) harvesting, 2) local movement of wood, 3) local storing & drying of wood, 4) chipping, 5) transporting woodchips to the point of use, 6) optional thermal drying, and 7) burning.

Moisture content in wood bio-mass typically ranges between 30 – 45 w-% when delivered to a power plant. The results of this study indicate that total costs for moisture content in Finland is annually some 50 M€ higher when using wood bio-mass with 45 w-% instead of 30 w-% by. Roughly half of this increase comes from transportation and another half from weakening burning efficiency. When the national bio-energy goal is achieved, the total market value of wood bio-mass is 500 M€. The calculations thus show how the significance

of moisture is only 10 % of the market value of wood bio-mass, opposed to a common understanding.

Actors in bio-energy field should understand that wood moisture has true significant only for small power plants that are not capable of utilising moist raw material. Larger power plants are typically capable of utilising air-dried wood bio-mass with moisture levels between 30-50 w-%. However, it is desired that the moisture content remains at roughly constant level. Continuous moisture content measurement would ease the optimisation of combustion process. Properly organised air-drying is the simplest and cheapest measure to decrease transportation costs and improve combustion.

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ENVIRONMENTALLY INNOVATION IN THE FUEL SECTOR: THE ROLE OF BIOFUEL FROM ALGAE

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ABSTRACT

Today, as it is commonly recognized, energy patterns lead to an unsustainable future, that concerns not only natural energy resources narrowness and scarcity but is strictly linked to greenhouse gas emissions (GHGs), mainly CO_2 ones. Burning fossil fuels is one of the main causes of energy natural resources depletion and climate changes. After power generation one, transportation is the second sector that considerably generates these phenomena. As per the above, policy makers efforts are more and more focused on how to effectively harmonize growing energy demand and climate change mitigation. In these scenarios, a valuable option is the increase of renewable energy sources utilization. Among these sources a relevant role is held by biofuels intending any fuel derived from biomass, living organisms (algae) or their metabolic byproducts (bovine manure). Biofuels of so called "third generation" seem to be a promising possibility to convert a low-input and high-yield no food feedstock into biofuels, mitigating the transportation sector influence on energy demand and climate changes.
The objective of this paper is to investigate the role of the third generation biofuels, their impact on existing transportation sustainability and linked emergent markets.

Keywords: Biofuels, sustainability, microalgae, environmental critical innovation

INTRODUCTION

As it is commonly recognized today energy patterns lead to an unsustainable future, that concerns not only natural energy resources narrowness and scarcity but is strictly linked to greenhouse gas emissions (GHGs), mainly CO_2 ones. It is not possible to encourage further fossil resources increment because consequent climate changes lead to local and/or global environmental disasters. It is estimated that exceeding the CO_2 atmospheric concentration limit of 450 ppm means to overpass the point of no return towards global warming and non-reversible environmental changes (Hansen et al., 2008; Rockström et al., 2009). This means that the use of fossil fuels must stop prior to deposits depletion.

According to the previous concerns and considering that burning fossil fuels causes approximately 60% (18 million metric tons, Mt) of total CO_2 emissions (30 Mt), their contribution to energy demand is equal to more than 80% (9.8 million tons oil equivalent -

Mtoe), models of low fossil fuels energy or low carbon economy must be realized (ITF, 2010; IEA, 2010). Among energy sector issues, the fuels production has significant criticisms because it highly depends on fossil sources. This awareness makes policy makers more and more engaged to find the right way to effectively harmonize the growing energy demand and climate change mitigation. In this paper fuel sector means the economical activities finalized to producing and delivering "energy" for transportation, that is all those systems for moving people or goods (family cars, trucks, airplanes, boats). In order to achieve the goal of low carbon economy, the innovations or the options explored for the energy sector looked upon: energy saving, energy systems efficiency improvement, switching to less carbon-intensive fossil fuels, capture and storage of CO_2 emissions and a wider use of renewable energy sources. The latter is a strategic option because it improves domestic energy self-sufficiency and security (particularly for countries importing many energy carriers), the economic stability and sustainability of energy needs and above all their use decrease the CO_2 atmospheric emissions.

A renewable energy source with a relevant role is biomass because it suitable to producing biofuels, intending any fuel derived from biomass, included living organisms (algae) or their metabolic byproducts (bovine manure). It is interesting to note that biomass was at the origin of fossil fuel origins and today is one of the best promising options to solve their crisis. It is a matter of fact, that using biomass for biofuels production is not a novelty but the interest in its development is directly proportional to oil price, oil availability and environmental protection. Biofuels can be grouped in 'generation', according to the type of biomass feedstocks and technology used. Up today there are three biofuels generations. The first refers to biofuels, which are produced from food crops treated with technologies, today well established, including transesterification (biodiesel form oil crop), fermentation (bioethanol from sugar or starch crops) and anaerobic fermentation (biogas from organic residues). Second generation relates to biofuels produced from a wider range of no-food lignocellulosic crops feedstocks. Utilized technologies include different options such as enzymatic production of lignocellulosic ethanol and pyrolysis-oil and syngas gas based fuels. Second generation technologies are not yet economically and technical aspects are still under development. Third generation, also called oilgae or algae fuel, refers to the possibility to convert a low-input and high-yield no food feedstock, like algae are, into biofuels. Also in this case the technical aspects affect the diffusion and the convenience of this last generation.
These preliminary considerations summarize the principal reasons why the currently energy patterns, and particularly fuel sector, are unsustainable. It is commonly argued that environmentally technical innovations stimulate the change toward environmentally friendly and sustainable patterns. The innovation is environmentally critical if it causes large reduction in environmental risks, represents a significant technical advances and involves favorable ratio of social and private returns.

In particular, the reductions in environmental risks have to consider a large populations and significant categories of risks as human health and natural ecosystems modifications. It is beyond question the importance of human health but also the modification of natural assets is imperative because we do not have any alternatives to the services provided from the Nature (for instance the service of waste neutralization, freshwater generation, clean air, new soil). Among the critical concerns of natural ecosystems, the biodiversity losses are

the most important risks. Furthermore, the technical advances should introduce a method of production absolutely new and we cannot consider as a significant advance the simple increasing of efficiency of the current technology.

The objective of this paper is to investigate the role of the third generation biofuels, their impact on existing transportation sustainability and linked emergent markets.
The paper is split in different sections. After a brief introduction, a first part presents an overview on first and second biofuels strengths and weaknesses which make necessary to consider the third generation. A second section regards the state of technology in the different phases of third generation biofuels production chain. In the last part and based on the results obtained, the authors illustrate the related effects of the applied technologies, if they will be able to modify fuel generation patterns, if they will be environmentally critical technology related to CO_2 emissions and if they will represent a chance for the emergent markets of bio-chemicals.

THE CURRENT SCENARIO OF BIOFUELS PRODUCTION

The renewable energy sources, as above, have to play a relevant role in the near future and among them the role of biomass will be significant because it gives the possibility to produce biofuels intending any fuel (combustible materials) derived, directly or indirectly, from biomass such as living organisms (algae) or their metabolic byproducts (bovine manure). A wide range of biomass (energy crops, food, short-rotation crops, agricultural waste, etc.) sources can be used to produce bioenergy and the type of biomass used influence the energy yield.

The use of biomass to produce biofuels is not a novelty and several reasons, such as concerns about the adverse effects of increase greenhouse gases, the dependence on fossil fuels, the continuous increasing of oil price and instability in political situation, justify the expansion of biofuel markets and the interest related to it. In fact, biofuel can be a good opportunity to government worried about the stability of their fuel imports or the long-term future of global oil production. It is estimates that the world energy demand will increase of 36% up to 2035, from the current 12,300 Mtoe to 16,700 Mtoe; we know that about 30% of total energy consumption is related to transport sector and we can estimate that this consumption is going to expand in parallel with the enlargement of transport demand (IEA, 2011). Over the 2006-2030 period, transportation accounts for nearly 80% of the total increase in world liquids consumption (EIA, 2010). All these reason s show that it is necessary to re-organize transport sector and that it is important to free it from dependence on fossil fuels and on the continuing increases in oil prices which will make it untenable in the long run. That is why in these last years great attention has been paid on liquid biofuels for transportation, mostly produced using agriculture and food commodities as feedstock.

Biofuels can be classified according to source and type. They may be solid (fuelwood, charcoal, wood pellets), liquid (ethanol, biodiesel, pyrolysis oils) or gaseous (biogas). They also can be divided in: primary biofuels that are used directly in their natural form and secondary biofuels (charcoal, ethanol, biodiesel, bio-oil, biogas) that have a great application also for transport sector. Table 1 illustrates the different methods of biofuels generations.

Table 1: Methods of biofuels generations.

First generation biofuels	- **Vegetable oils** - **Ethanol** - **Biodiesel**
Second generation biofuels	- **Lignocelluloses ethanol** - **Enzymatic bioconversion of vegetable oils** - **Hydrogenation Biodiesel** - **Synthetic fuels**
Third generation biofuels	- **Energy crops for bio-alcohol** - **Hydrogen from algae** - **Oil from algae**

Source: personal elaboration by the authors.

The major liquid biofuels currently produced are ethanol, with approximately 76 billion liters in 2009 obtained by feedstocks containing significant amount of sugar or materials that can be converted into sugar, and biodiesel (16 billion of liters in 2009), generated by vegetable oils, with ethanol production being far greater at the global scale (Eisentraut, 2010; REN21, 2010; RFA, 2011). In fact, actually, biodiesel production is dwarfed by that of ethanol. The first generation biofuels are based on a well-established technology, which is widespread in the world. In Brazil, for example, ethanol from sugarcane replaces about 50% of gasoline for transportation.

Brazil and United State of America (USA) are the most important producer of ethanol respectively by sugarcane and corn, but in European Union (EU) it is estimated a future ethanol production approximately equal to 12 billion liters/year by 2012 (Eisentraut, 2010; REN21, 2010; RFA, 2011).

Brazil and USA accounted for 88% of global ethanol production in 2009. Ethanol production in USA was about 41 billion liters in 2009 (about 54% of global production) and corn-based USA ethanol displaced more than 360 million barrels of imported oil for gasoline production. Owing to the increase in sugar prizes and the adverse weather conditions, ethanol production in Brazil has decreased from over 27 billion liters in 2008 to 26.3 billion liters in 2009 (REN21, 2010; RFA, 2011).

Almost 80% of the world's production of biodiesel occurs in Europe where biodiesel plays an important role among biofuels consumption. France has increased its production by 34% in 2009 to surpass Germany, that was the leading country in manufacturing biodiesel from rapeseed in EU thanks also to a strict cooperation with automobile industry (RFA, 2011). The production of biodiesel has increased in percentage terms in countries such as Argentina, Austria, Colombia, Indonesia, Spain and United Kingdom while has decreased in other top countries such as USA, Italy and Belgium.

In order to incentive the use of renewable resources, in early 2008, EU has set a legal minimum of 10% renewable fuel share for all transportation fuels by 2020, which would amount about to 34 Mtoe or roughly 60 billion liters if all biofuels are ethanol. In addition to the target of 10%, in the EU for share of transport energy from renewable includes Belgium and Croatia (5.75% by 2010), France (10% by 2015) and Portugal (7% biodiesel by 2010).

Furthermore, only alternative fuels that meet established GHG savings and limits on biodiversity impacts will count towards the legal quota, thus limiting the import of biofuel blends not conformed to European quality standards.

PROS AND CONS OF BIOFUELS PRODUCTION

One of the parameter used to judge the opportunity to produce biofuel is the *fossil energy* balance, i.e. the ratio between the energy content of the biofuel and the fossil energy consumed in its life cycle. A fossil energy balance of 1.0 means that it requires as much energy to produce a litre of biofuel as it contains (no net energy is gained or lost); a fossil fuel energy balance of 2.0 means that a litre of biofuel contains twice the amount of energy as that required in its production. Conventional gasoline and diesel have a fossil energy balance of around 0.8-0.9, because some energy is consumed in refining crude oil into usable fuel and transporting it to the markets. So, we can consider the efficiency in biofuels and the reduction in the dependence from fossil fuels if the energy balance exceeds that numbers.

Just as different crops have different yields in terms of biofuel per hectare, wide variations also occur in terms of energy balance and greenhouse gas emission reductions across feedstock, locations and technologies. For example sugar-cane ethanol from Brazil has a much more favorable energy balance; for each ton of sugarcane, the fossil fuel energy input is equivalent to 210 MJ and the energy output close to 2,190 MJ, yielding an energy output ratio around 9; this depends on the fact that in that country ethanol is processed using biomass residues (bagasse) from sugar cane as energy input.

The net energy balance is an important consideration with regard to determining the net greenhouse gas emissions from the use of a biofuel, even if studies have not totally demonstrate that there is a point to point relationship between net energy balance and net greenhouse gas emissions. Lots of the considerations depend on system boundaries; for example, most recent analyses (Hill et al., 2006; Ghallagher, 2008; Howarth and Bringezu, 2009) show a positive benefit on net greenhouse gas emissions from using liquid biofuels, especially for producing ethanol from sugarcane or biodiesel from palm oil, if peat soil conversion and indirect land use changes are not considered.

The production of biofuels have shown, during the years, some limits that have changed the optimistic first impression that they could have been the perfect response to increasing demand of energy and the perfect candidate to replace gasoline and diesel fuels. Production of biofuels may have lots of environmental consequences: changes in the land use, expansion in agriculture, changes in agriculture practices, transportation of biomass used to make biofuels, conversion of the biomass into fuels and disposal of the remain waste

materials after fuels are made. Not less important is the effect, from an economical and social point of view, of the conversion of land on no-food agriculture.

Environmental concerns related to the production of biofuels have been discussed in lots of studies (Azar and Larson, 2000; FAO, 2008; Howarth and Bringezu, 2009) and now they represent the most controversial factors of biofuel production.

First of all, the reduction of greenhouse gas emission was the first and prominent objective of biofuel policies. All over the world ambitious reduction goals have been stated; for example UE had first fixed an objective of 45-60% by 2015 that it is now changed into 50% by 2017.
The basic question is whether the use of biofuels and thus the use of land for feedstock production saves more GHG emissions by displacing fossil fuel than that saved by leaving land in its existing use even while continuing to use fossil fuels. In particular this affect the forest land modification (Howarth and Bringezu, 2009).

As we mentioned before, GHG emissions are driving the production of biofuels and they are the major problem on which the most efficient refining technologies are based. The impact of biofuels on greenhouse gas emissions varies widely, depending on where and how the various feedstocks are produced, the logistics concerns, the technology and the type of energy used.
In any case, we might think that as biofuels are produced from biomass they should be carbon neutral as their combustion only returns to the atmosphere the carbon fixed by the plant during its growth. But, in reality, different biofuels can vary in the GHG balances when compared with fossil fuels and, sometimes, they can determinate more GHG than fossil fuels do. The agricultural practices, such as fertilizing, pesticide use, irrigation technology and soil treatment, influence net GHG emissions and can determine a balance that may not necessarily be positive or as positive as it is often initially assumed. For example a problem is the nitrous oxide (N_2O) that is realized by nitrogenous fertilizer as land conversion. A full consideration of N_2O emissions can transform the net GHG emissions of biofuels from positive to negative. Moreover, the land conversion itself can have some negative effects on GHG emissions that sometimes can double the GHG emissions respect to fossil fuels because of deforestation.

Secondly, large areas of land are necessary to produce adequate amount of biofuels to substitute a significant quantity of fossil fuels. For example, it is estimated that the 10% substitution of gasoline and diesel fuel requires 43% and 38% of current cropland area in USA and Europe respectively (Righelato and Spracklen, 2007). As even this low substitution level cannot be met from existing arable land, forests and grasslands would need to be cleared to enable production of the energy crops and this may place additional strains on the environment. Moreover, if we stress the opportunity to use sustainable practices for crops cultivation, needed area is larger.

Enlargement of land use can have immediately and direct environmental and social consequences: FAO report (2008) stated that while biofuels will offset only a modest share of fossil energy use in the future, they will have much bigger impacts on agriculture and food security.

The use of some food crops (maize, sugar, oilseeds, palm oil) for the production of biofuels has as consequence the increase of food prices. Between 2006 and early 2008, corn prices rose from $87 USD per ton to $217 USD per ton (FAO, 2008). The growth of some agricultural products, as new and significant source of demand for biofuels, contributes, with other factors, to higher prices in agricultural commodities. So, we can say that there is a strong competition between food and biofuels for raw materials appropriation and probably it is going to grow in parallel with the growth of biofuel production in lands suitable of food-agricultural production. This is one of the most controversial points to be analyzed when we want to weigh the pros and cons of no-food agriculture. In fact, from one side biofuel is viewed as an opportunity of promoting access to energy in rural areas and supporting developing countries agriculture sector and this is shown for example by the important role that ethanol production from sugarcane has for Brazilian economy. From another side there is the risk that higher food prices could threaten the food security of the world's poorest people that paid more the adverse effect in terms of lack access to energy, food, land and water.

Risks for biodiversity and environmental problems related to an intensive form of agriculture (water consumption due to irrigation, use of pesticide, no set aside) need to be discussed if we want to evaluate whether the benefits of devoting land to biofuel exceeds those of leaving that land in its existing use or potentially improving its existing use in other ways. To preserve biodiversity, EU provisions prohibit conversion of wetland to no-wetland and forest to other biofuels uses, but would permit harvest of forest or conversion of those unmanaged forests that do not meet standards for native vegetation to tree plantations.

It is estimated that, in the short term, the introduction of good agricultural practices and the conversion of large areas of land back to secondary forest provide other environmental services (such as prevention of desertification, provision of forest products, maintenance of biological diversity, regional climate regulation), whereas conversion of large areas of land to biofuel crops might place additional strains on the environment. Also the irrigation is an adverse effect of no-food agriculture, as the oil problems can be translated into the water problems (Service, 2009). All these problems show that we need to pay attention on cost-benefit analysis. Infact the efficiency of biofuels depends mainly on two factors: the net reduction in fossil carbon emissions arising from use of agricultural derived biofuels and the effect of alternative land-use strategies on carbon stores in the biosphere. Some studies showed that in a short term (30 years or so) it could be better to improve the efficiency of fossil fuel use, to conserve the existing forests and to restore natural forest and grasslands habitat on cropland that is no needed for food. Forestation of an equivalent area of land would sequester two to nine times more carbon over 30 year period than the emissions avoided by the use of biofuel (Righelato and Spracklen, 2007). According to this consideration, the emissions cost of liquid biofuels would exceeds than of fossil fuels and, sometimes, it is better to convert large areas of land back to secondary forest in order to provide other environmental services, such as prevention of desertification, provision of forest products, maintenance of biological diversity, regional climate regulation.

Together with the above-mentioned problems, the production of biofuels shows some other defects. One is related to the intrinsic characteristics of ethanol; ethanol is in fact corrosive and hygroscopic and these characteristics make difficult its storage and transport.

Also biodiesel shows some problems. For example, the presence of some fatty acid methyl esters tends to give it poor cold flow properties. Moving to non-oxygenated biofuels can overcome many of the issues of corrosion and cold-flow inherent in oxygenated biofuels.

Another important consideration concerns the small role of biofuel in the context of total energy consumption as they supplied only for 0.4% in 2006 (IEA, 2011). In terms of liquid fuels used for transportation, biofuel contributed 1.8% globally, with fossil fuels making up 92% of global use. In the 2030 scenario, it is forecast an increasing in the coal share at the expense of the oil while, for the some period, biofuels are projected to represent the still modest share of 3.0-3.5 % of global transport energy consumption (FAO, 2008).

According to these considerations, biofuels feasibility and economical convenience mainly depends on the political impulse towards this sector also in terms of incentives and subsidies and technological innovations, in order to eliminate critical states previous analyzed.

Actually, biofuel tax exemptions exist in ten EU Countries at last (Belgium, France, Greece, Ireland, Italy, Lithuania, Slovenia, Spain, Sweden, UK), in the OECD Countries Australia and Argentina and in several developing Countries (Argentina, Bolivia, Colombia, South Africa) (REN21, 2010).

The OECD has estimated that the elimination of all biofuel subsidies and mandates would reduce US ethanol production by roughly 20% on average compared to the level that ethanol would otherwise average in 2013-2017.

Technological innovation can lower the costs of agricultural production and biofuel processing. Investment in Research and Development (R&D) is critical for the future of biofuels as economically and environmentally sustainable source of energy.
In this sense, the tendency is towards new generation of biofuels able to balance economy and ecology. Since these fuels can be produced from biomass with much greater efficiency than for ethanol, less land is needed to produce an equivalent amount of energy. Greenhouse gas emissions and other environmental consequences associated with land conversions and intensive agriculture are reduced accordingly, as is the potential competition with food production.

The second generation biofuels use biomass not used for food production and, in this sense, represent a great opportunity to overcame lots of debates on pros and cons the use of first generation biofuels. In fact, lignocellulosic biomass is more resistant and it can be used completely as the entire crop is available as feedstock for conversion to fuel. On the other side, they have some problems related to the lack of highly efficient enzymes for converting cellulose. Moreover, lots of the species developed (jatropha curcas and switchgrass), although the advantage of not competing with the food market, are considered invasive or potentially ones and may have negative impacts on water resources. In any case,

investments are direct to the development of this biofuels; in particular international investors are rushing to establish large areas of jatropha cultivation in developing countries because of its great adaptability and potentiality.

In any case, as we mentioned above, the new tendency is towards third generation biofuels that refers to the possibility to convert a low-input and high-yield no-food feedstock into biofuels. Algae offer the potential for higher energy yield from lipids that would be cultivated using salt and/or fresh water in areas not currently used for food agricultural production so their use can reduce or eliminate food-fuel competition.

ALGAE BIOFUELS OUTLOOK

The term algae include macroalgae - seaweed- and a vastly diversified group of microorganisms known as microalgae. Algae can be aquatic or subaerial when instead to be immerged in the water they are exposed to the atmosphere. They show a good tolerance for a broad range of environmental conditions such as pH, temperature, turbidity, oxygen and carbon dioxide concentration. Due to these attitudes and to their carbohydrate (8-64% on dry matter), protein (6-71% on dry matter) and lipid (15-75 on dry matter) content algae are minor sources of foods, feeds and high-value nutraceuticals, pharmaceutical and other bioactive compounds (Bart, et al., 2010; Becker, 2007; Chisti, 2007). The growing interest in algae is, as just mentioned before, their potentiality to provide different types of biofuels including biohydrogen, methane from thermal gasification or anaerobic digestion of algae biomass; bioethanol by fermentation; bio-oil by pyrolysis and biodiesel by trasbesterifications of algae oil fraction (Figure 1).

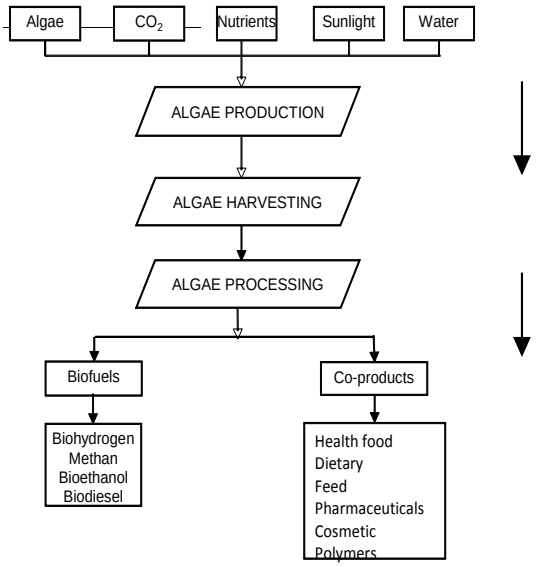

Figure 1: Integrated algae biomass processing (personal elaboration by the authors).

Biodiesel and bioethanol are the main promising options for the future sustainability of transportation sector but considering that fossil diesel is the fraction most used in transportation sector in this paper the authors focus their analysis on biodiesel. This choice

is based on worldwide diesel and gasoline consumption figures in 2009 equal respectively to more than 30 and 27 million of barrels per day, and because of the most commonly argued approach of algae exploitation is to obtained biodiesel rather than others biofuels (BP, 2010; Chisti, 2007; Lardon et al., 2009; Thurmond, 2011). Furthermore because of oil yield from macroalgae up today is less profitable than microalgae the authors in their analysis refer to microalgae (Bart, et al., 2010).

Microalgae are microscopic organisms that grow in fresh, salt or wastewater. The three most important classes of microalgae in terms of abundance are the diatoms (Bacillariophyceae), the green algae (Chlorophyceae), and the golden algae (Chrysophyceae). Microalgae seems to be a miniature biochemical factories, they are more photosynthetically efficient than terrestrial plants and they are efficient CO_2 fixers alike from atmosphere, from discharges gases (power plants) and soluble carbonates (Na_2CO_3 and $NaHCO_3$). To produce one ton of microalgae biomass approximately 180 t of CO_2 are required. Microalgae are able to double their biomass within 24 hours, so they show a very short harvesting cycle (1-10 days) allowing a higher oil yield compared with the best oil crops (table 2) (Andrate et al., 2011; Bart et al., 2010). Due to their just mentioned adaptability to a wide range of climate conditions, including wasteland and/or wastewater, they can be cultivated also in desert areas without competing with agriculture land use and food crops.

Table 2: Oil crop productivities.

Plant	Oil kg/ha	Oil L/ha
Corn	**143**	**172**
Soybean	**374**	**446**
Jatropha	**1,730**	**1,892**
Coconut	**2,260**	**2,689**
Oil palm	**5,000**	**5,950**
Microalgae[a]	**136,900**	**157,435**
Microalgae[b]	**58,700**	**67,505**

a) 70% oil (by wt) in biomass. b) 30% oil (by wt) in biomass.
Source: Burt et al., 2010; Chisti, 2007.

All these characteristics and considering that since 2007 the biodiesel demand has exceeded the vegetable and animal oil supply, the potentiality of microalgae has to be investigated despite technical and economic problems still affecting oilgae production and its costs.

Oilgae production chain is composed by several phases such as microalgae cultivation, harvesting, oil extraction and subsequent transformation in biodiesel. It is important to underline that up today the microalgae biomass production useful for biodiesel is obtained in pilot scale plants (from 10 meter to 2 hectares). This does not mean that there is no algae production, quite the contrary, worldwide algae production (few thousand tons of algae per year) are used in niche but profitable markets (up to 800,000 USD/t) such as health food, dietary, pharmaceutical or cosmetic ones (Bart, et al., 2010; Thurmond, 2011).

Sunlight, CO_2, water and nutrients such as nitrogen (N), phosphorus (P), and potassium (K) are the principal inputs needed to make microalgae growth. Silica and iron, as well as several trace elements, may also be considered important nutrients as the lack of one can limit their growth.

Different important factors influence the productivity of microalgae biomass first of all microalgae species (fatter and faster), light and insolation conditions (to improve the photosynthetic process) and the amount nutrients (determinant growth rate and chemical composition) (Pfromm, 2011). The key factors determining the growth algae rate are summarized in table 3.

Table 3: Factors influencing growth algae rate.

Algae species	**Algae species depend on the type of products you want to produce. "Fatter and faster" approach is at the base of the choice of high oil content algae with the faster growth rate.**
Aeration and CO_2	**The algae need aeration to fix CO_2 and to grow. To improve growth rate it is necessary a secondary CO_2 source for instance flue gas from power plant.**
Medium and Nutrients	**The composition of land and/or water determine growth algae rate. If water from farm-run off or waste water effluent are used, their high level of nitrogen stimulate the algae growth.**
Light	**Normally sunlight is needed for photosynthesis process. Artificial light sources are introduced to stimulate algae growth in same demonstrative pounds.**
pH level	**To grow optimally algae need a pH ranging between 7 and 9. This range could be influenced by CO_2 and nutrients inputs.**
Mixing	**Mixing is necessary to ensure that all algae cells are equally expose to light and to prevent sedimentation**
Temperature	**Warm temperature ranges are often required by several algae species to grow**

Source: personal elaboration by the authors on data by Thurmond, 2011.

They are cultivated in various types of ponds (such as closed or open raceway-ponds) and photobioreactors. Raceway open pond is the cheaper system, microalgae oil estimated production costs in open raceway ponds ranges between 2.4-4.5 $/L. Critics points of these systems are the vulnerability to contamination by other microorganisms (bacteria and/or other algae species) and the difficulty to control biocultural conditions (pH, light, carbon dioxide, temperature). Closed-ponds system is preferable but researches and studies show

the difficulty of producing large amount of algal biomass in such a plant and above all costs increase too much losing competitiveness with the photobioreactos. They, an enclosed and light culture vessel, are much more expensive systems than raceway open ones. Estimated oil production costs ranges between 5.2 -10 $/L (Thurmond, 2011). The principal technological goals during this phase are the improvement of microalgal biomass growth with high oil percentage and the development of the best and cheaper microalgae growing system able to achieve commercial success in sufficient quality and quantity to meet commercial scale viability in biofuels markets in the next 3-5 years.

The subsequent phase in oilgae production chain is harvesting and dewatering. Several options are available with different efficiency and cost level. Sedimentation, filtration, froth floatation, flocculation and centrifuges are commonly cited algae harvesting methods. Sedimentation is often the first step used in harvesting utilizing gravity to operate a preliminary separation of algae from water. Filtration due to dimensions of microalgae does not work well as froth floatation. Centrifuges systems are today the most used despite their capital and operating high costs (0.6 $/L) especially for energy inputs (3 kWh/L) (Thurmond, 2011; Schenk at al., 2008). The main problem of this method is the efficiency because algae are small portion of the total mixture centrifuged (1-4 g/L of mixture). When algae are harvested and dewatered oil extraction can be made by different methods such as traditional mechanical crushing, solvent extraction (with hexane and benzene), supercritical CO_2, microwave, ultrasonic cavitation and cellular decompression. Also in this case they differ for efficiency and costs. Hexane extraction system is the most used even if ultrasonic cavitation is the emerging trend in oilgae industry as it can accelerate the extraction processes. Microwave technologies are also considered a good option but its high capital and energy costs make it too much expensive to use. Like other vegetable oil, algae oil cannot be directly used in diesel engines above all because of its high viscosity. The algae oil obtained has to be transesterified to achieve the right standards parameters required in USA and/or EU for fossil diesel.

FINAL REMARKS

The sustainability of energy system represents one of the most important problems in the next future above all in transportation sector characterized by a high dependence from fossil fuels. To achieve this sustainability means to make compatible during the time, energy demand with energy supply without compromise natural equilibrium. Unfortunately there is not *one* solution rather than a *mix* of solutions by which to solve this kind of problem. Moreover, the mix has to be contextualized according to the realty, possibility and potentialities of specific situation. In this general context biofuels represent an innovative good options and in order to understand their role, in the first part of this paper, the authors have briefly described the evolution of biofuels of first and second generation highlighting pros and cons. Subsequently they focus on third generation with particularly attention on algae biodiesel. At the end of this review, authors have analyzed the contribution of biofuels innovation with the aim to verify if they represent environmental critical innovations able to get transportation sector towards sustainability. Based on the definition of environmentally critical innovation that is a type of innovation able to cause large reduction in environmental risks, to represent a significant technical advances and to

involve favorable ratio of social and private returns, the authors have been compared the three biofuels generations (Table 4).

Table 4: The role of environmental critical innovation in the biofuels production.

	Reduction in environmental risks	Technical advances	Social effects	Market developments
First generation	**Low**	**High**	**Negative**	**Low**
Second generation	**Low**	**High**	**Medium/low**	**Low**
Third generation	**High**	**High**	**Medium/high**	**High**

Source: personal elaboration by the authors.

Environmental critical innovation boosts shifting from the first to the third biofuels generation. The main limit of first generation biofuels is the social effects (food and cropland competition) followed by a low reduction in environmental risks. In fact several first generation biofuels input/output analysis are available and, despite the difficulties to compare final results, they often show that CO_2 fixed by the energy crop are equal or exceed CO_2 emitted during production and consume phases or in the same way energy inputs during all phases (agricultural, production and consume) are higher than energy value of biofuels produced. Second biofuels generation overpass the social effects but the feedstock logistic difficulties; high production costs mainly due to the investment and moderate reduction in environmental impacts still limit them. As concerning algae biodiesel (third generation) it seems to be the promising environmentally critical innovation. The state of the art and the medium term scenario available show that algae exploitation can accomplish two environmental problems such as CO_2 sequestration and wastewater reduction. Algae need CO_2 to grow and can be grown in wastewater reducing two important environmental risks. They show high yield rates, high oil content and they are not in competition with food production, cropland and freshwater sources. Quite the opposite algae cultivation in arid and deserted land could contribute to the social and economic development of those areas. Moreover, algae biodiesel is accompanied by joint production of several profitable co-products (Figure 1) already present on existing value added markets. As just mentioned in previous paragraphs, today algae production is finalized to obtain profitable products such as omega3, carotenoids and other useful bio-chemicals. Up today, in terms of values the much more profitable algae commodities are those at the top of a pyramidal scheme at the base of which there are low value products such as algae oil useful in biodiesel production. The paradox is that the by-products of these emergent markets are source for biodiesel industry and market, which are suffering a supply feedstock crisis. The role of these emergent markets is also important because bigger are their return bigger will be the capacity to invest in R&D in algae biofuels field improving their techniques of production and making lower their production costs. These markets could be the bridge to include algae biodiesel in the mix of options useful to transportation sustainability.

CONCLUSION

At the end of this analysis, the authors believe that in third generation biofuels field, innovations still present a large margin of action. The main challenger to exploit algae biomass could be summarized in these words *fatter, faster, cheaper and better*. Fatter and

faster because it is necessary to identify and/or modify genetically the algae species with high oil content able to be harvested daily rather than few time a week. Cheaper and better because costs and efficiency in algae biomass production have to be progressed in order to became profitable for companies and so available on fuels markets. In any case, it is necessary to remember that joint to environmental critical innovations, such as algae biomass, a concrete contribution to make sustainable the global energy problem arrives *faster and cheaper* from energy saving actions.

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GREEN SUPPLY CHAIN MANAGEMENT WITH LINGISTIC PREFERENCES AND INCOMPLEE INFORMATION

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ABSTRACT

As firms move toward environmental sustainability, management must extend managements efforts to improve environmental practices across the supply chain. The selection of a suitable green supplier according to green supply chain management criteria (GSCM) is essential for the sustainable development of manufacturing firms. The objective of this study was to select an optimal alternative in the presence of incomplete information and linguistic preferences using multiple GSCM criteria. The goal of GSCM is to reduce a firm's pollution and other environmental impacts. In the proposed method, the weights of GSCM criteria and alternatives are described using linguistic preferences that can be resolved with fuzzy set theory. Subsequently, the rank of each alternative was calculated from incomplete information by applying a grey degree. Moreover, a case study was used to resolve the proposed method, and the results and managerial implications of the analysis are discussed in detail.

Keywords: grey degree, fuzzy set theory, firm's green supply chain management

INTRODUCTION

In recent years, environmental management has evolved to include boundary-spanning activities in the supply chain, and both upstream and downstream activities are included in green supply chain management (GSCM) (Sarkis, 1998; Lee et al., 2009). A limited understanding of GSCM has hindered the development of a widely accepted framework that characterizes and categorizes a firm's environmental activities. The European Union has established a variety of environmental policies, including RoHS (the restricted use of hazardous substances in electrical and electronic equipment) and WEEE (waste electronics and electrical equipment) Directives. These directives ban manufacturers, sellers, distributors and recyclers of electrical and electronic equipment from launching new equipment that contains hazardous materials on the market (Tseng, 2009a; Tseng 2010a). While WEEE directives are aimed at the life cycle of the product, RoHS is targeted at the

product design stage. Although environmental regulations and mandatory programs have been implemented, pressure to protect the environment also comes from other external stakeholders.

Currently, a wide variety of studies on GSCM can be found in the literature (Zhu et al., 2008; Srivastava, 2007). Srivastava (2007) defined GSCM as a combination of environmental and supply chain management (SCM) activities, including product design, material selection, manufacturing processes, final product delivery and end-of-life product management. Moreover, through GSCM, firms can select from a wide variety of suppliers and leverage resources throughout the firm to eliminate the environmental impacts of supply chain activities. Firms typically expect their suppliers to go beyond environmental compliance and develop efficient, green product designs. In addition, suppliers are expected to assess the life cycle of a product. Nevertheless, the firm's suppliers must satisfy GSCM criteria under the constraint of incomplete information and subjective human preferences (uncertainty); however, this phenomenon has not been thoroughly examined.

GSCM philosophy focuses on how firms utilize the supplier's processes and technologies, as well as the supplier's ability to integrate environmental concerns and enhance the firm's competitive advantage (Vachon and Klassen, 2008). However, to study and advance the body of knowledge related to GSCM, identification of appropriate measures is necessary. To effectively and empirically advance the theory, greater attention must be focused on employing multi-criteria evaluations, assessing the validity of criteria and modifying unacceptable criteria through extensive literature reviews (Tseng et al., 2009b; Lee et al., 2009). Hence, in this study, a number of different criteria that can be used to evaluate GSCM practices were integrated, and a literature review on supply chain and environmental management was performed. Firms can benefit from the development of reliable and valid criteria, and the practitioner can apply these criteria as benchmarks to attain continuous improvement. One objective of the present study was to assist firms in understanding the criteria and implementation. However, the uncertainties and incomplete information are often encountered in the implementation process. In the process of GSCM, the selection of green supplier is always encountered, the multi-criteria decision making (MCDM) tools are always proposed to be applied in the process (Tseng et al., 2008).

In real systems, MCDM is often based on subjective preferences or incomplete information. Grey theory is superior for the theoretical analysis of systems with imprecise and incomplete information within a system of evaluation (Tseng 2010b). Moreover, the evaluation system having incomplete information is so called grey system and the triangular fuzzy numbers in grey system represents a set of numbers with less complete information, the system is

always represented as lack of information. Hence, the grey possible degree is to evaluate the incomplete information. The principles of the available theories and modeling schemes for the prediction and diagnosis of an uncertain situation are summarized, and the practical applications of theories and linguistic preferences are reviewed. People often employ natural language to express thoughts and subjective perceptions; however, the meaning of words in natural languages is often vague. Although the meaning of a specific word may be well defined, when that word is used to define a set, the boundaries of the set can become uncertain. Hence, the proposed method uses fuzzy set theory to appropriately express the determination of human judgment in GSCM criteria. The second contribution of this study is the development of a hybrid approach for the establishment of GSCM criteria for the selection of an optimal alternative.

In an effort to determine the uncertainty in the proposed model, GSCM criteria were integrated and an optimal alternative was selected. This paper contributes to GSCM literature by developing valid and reliable criteria based on information obtained from GSCM literature and experts in the field. Moreover, this study developed an approach based on grey theory for the determination of linguistic preferences. In section 2 of this paper, a literature review of GSCM practices is provided. In addition, the methodology used to develop GSCM criteria was validated and is presented in Section 3. Section 4 presents the results of this study, and the implications of the results are discussed in section 5. The paper is concluded in section 6 by summarizing the results, implications, limitations and potential topics of future research.

PROPOSED GSCM CRITERIA

Contributions from industry and academia, along with the results of an extensive literature review, were used to establish 16 criteria of an optimal supplier (Li et al., 2006; Tseng et al., 2009b). Selection of appropriate suppliers in GSCM requires battery of evaluation criteria, which include such information as customer focus, competitive priority, green purchasing, information technology, and top management support of a firm. Srivastava (2007) described GSCM as combining environmental thinking and supply chain management and defines it as including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumer, and end-of-life management of the product after its useful life. A firm must have outstanding competitive priority in order to perform well management in production, such as producing high quality products with excellent logistics arrangement. The competitive priority is closely related to top management support that requires strategic purchasing. As such, the present study will view GSCM a complex, interactive process of many different resources with multidimensional, interdependent

criteria (Sarkis, 1998; 2003).

To ensure that the profitability of the supplier (C2) is an important part of the firm's practices, GSCM has become critical in establishing value-added content (Kathuria, 2000; Johnston et al., 2004; Yao et al., 2007). Moreover, the reliability of delivery (C1), defined as the ability to meet delivery schedules or promises, and the ability to react quickly to customer orders, is critical to improving the firm's customer service. The product conformance quality (C5), defined as the ability of the firm to satisfy the customer needs, is critical to the firm's success (Chase et al., 2001). Tan et al. (1998) explored the relationship between supplier management, customer relations and organizational performance, and used purchasing, quality, customer relations and relationship supplier closeness (C3) to evaluate the suitability of a supplier selection model. Sarkis (1998) categorized environmentally conscious business practices into five major components including green design (green design (C8)), life cycle analysis, the total quality of environmental management and compliance with environmental standards such as ISO 14000 (C11).

Researchers have included internal green production (C12), clean production (C14) and the quality of internal service (C7) as GSCM criteria, and the supplier's purchasing perspective has also been addressed.. Carr and Smeltzer (1999) documented how firms with strategic purchasing plans foster long-term, cooperative relationships, and achieve greater responsiveness to the needs of their suppliers. Zhu and Geng (2001) studied Chinese firms and examined their methods of environmental development in business practices such as green purchasing (C9). Among the supplier selection models currently in use, environmentally preferable bidding and life cycle assessment (C10), which assesses the impacts of green purchasing and their financial consequences through the entire product life-cycle, are the most popular. However, supplier flexibility (C6) is a complex and multi-dimensional capability that requires firm-wide effort to increase the firm's responsiveness, reduce waste and limit the firm's environmental impact (Dreyer and Gronhaug, 2004). Chen, et al. (2006) identified many quantitative and qualitative factors such as quality, price and flexibility, and concluded that delivery performance must be considered in the determination of the optimal supplier. Humphreys et al. (2003) identified environmental criteria that influence a firm's management support services (C13) and developed knowledge-based environmental management system requirements (C16) to integrate the environmental criteria and support the supplier selection process.

GSCM capabilities are ‘‘complex bundles of individual skills, assets and accumulated knowledge exercised through production processes, that enable firms to co-ordinate activities and make use of their resources’’ (Olavarrieta and Ellinger, 1997). Moreover,

GSCM is essential to the competitive advantage of a firm. GSCM involves the flow of finances, logistics, and information, as well as the ability to integrate relationships and green technology (C4), and to reduce the use of hazardous products in the production process (C15). Figure 1 presents the hierarchical structure of the framework used to evaluate a firm's GSCM. The framework consists of a MCDM analysis based on fuzzy set theory and grey degree, and can be used to select optimal suppliers (Chen and Tzeng, 2004; Zhang et al., 2005; Li et al., 2007). Moreover, fuzzy set theory was used to eliminate the linguistic preferences of subjective judgment (Zadeh, 1965; Tseng et al., 2008; Tseng, 2010a). The proposed framework is based on the following criteria: (C1) reliability of delivery; (C2) profitability of the supplier; (C3) relationship to the supplier; (C4) green technology capabilities; (C5) conformance quality; (C6) flexibility of the supplier; (C7) service quality; (C8) green purchasing capabilities; (C9) life cycle assessment; (C10) green design; (C11) green certifications; (C12) internal green production plans; (C13) management support; (C14) green production; (C15) the reduction of hazardous materials in the production process; (C16) environmental management systems.

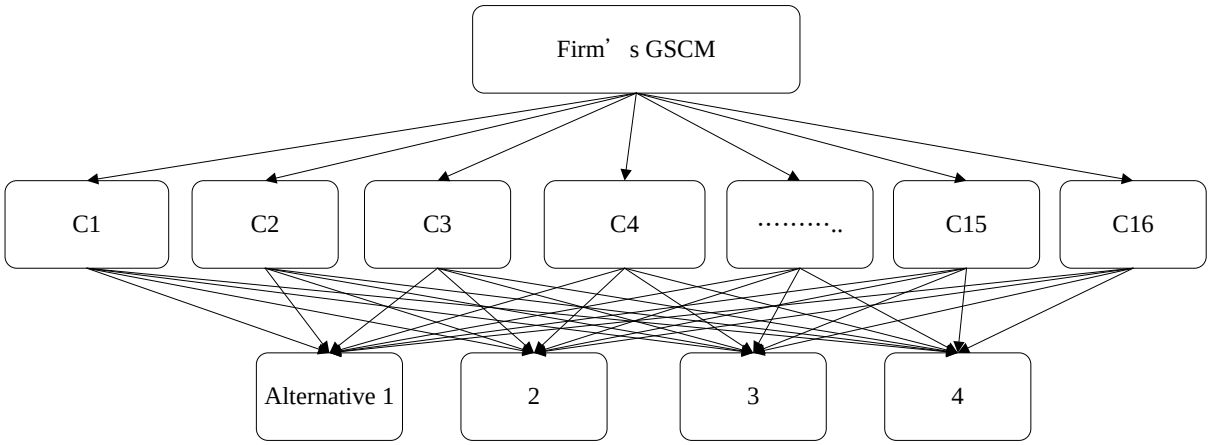


Figure 1. Hierarchical structure

METHOD

Researchers describe GSCM as a strategic, decision-making perspective used to improve the performance of a firm. This study focused on GSCM criteria and their relevant associations, as described below. The definitions of fuzzy set theory, grey theory and the procedures of the proposed approach are also briefly discussed.

Fuzzy set theory

Fuzzy set theory (Zadeh, 1965) is a mathematical theory designed to model the fuzziness of cognitive processes. It is essentially a generalization of set theory, where the classes lack sharp boundaries. The membership function $\mu_A(\mathrm{x})$ of a fuzzy set operates over the range of real numbers on the interval of [0, 1].

An expert's uncertain judgment can be represented by a fuzzy number. A TFN is a fuzzy number with a membership function that is defined by three real numbers (*a, b, c*), where *a*, *b*, and *c* are real numbers and $a \le b \le c$. This membership function is illustrated in Fig. 2 and described mathematically below.

In the proposed method, the linguistic preferences used to derive the priorities of the alternatives and the grey numbers used to establish the selection criteria were uncertain. The triangular fuzzy membership function employed in the proposed model is presented as follows (Lin et al., 2007).

Definition 1. A TFN $\tilde{\mathrm{N}}$ was defined as a triplet (a*, b, c*), and the membership function $\mu_A(\mathrm{x})$ was defined as:

$$\mu(x) = \begin{cases} 0 & x < a \\ (x-a)/(b-a) & a \le x \le b \\ (c-x)/(c-b) & b \le x \le c \\ 0 & c \le x \end{cases} \tag{1}$$

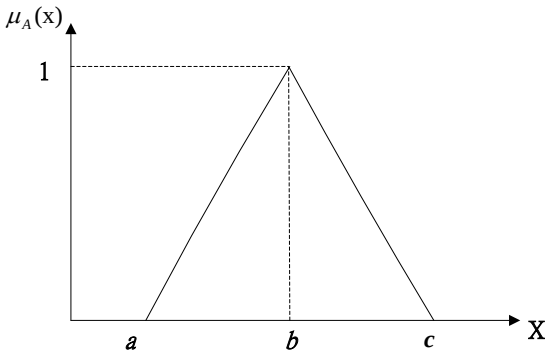


Figure 2. A TFN A= (*a, b, c*)

Therefore, *a, b*, and *c* represent the lower, mean and upper bounds of the TFN. The

membership function represents the degree to which any element (x) in domain X belongs to fuzzy number A.

Grey theory

Grey theory is a mathematical theory derived from the grey set and is an effective method used to resolve uncertainties in discrete data (Deng 1989). In this study, the basic definitions of grey systems, sets and numbers were applied(Tseng, 2008).

Definition 2. A grey system contains incomplete information and is represented by a set of TFNs. In the proposed model, X is the universal set, and G of X is a grey set defined by $\overline{\mu}_G(x)$ and $\underline{\mu}_G(x)$.

$$\begin{cases} \overline{\mu}_G(x) : x \to [0,1] \\ \underline{\mu}_G(x) : x \to [0,1] \end{cases} \tag{2}$$

$\overline{\mu}_G(x) \geq \underline{\mu_G}(x), x \in X, X = R, \overline{\mu}_G(x)$ and $\underline{\mu}_G(x)$ are the upper and lower membership functions of G after defuzzification, respectively. When $\overline{\mu}_G(x) = \underline{\mu}_G(x)$, G becomes a fuzzy set. Thus, grey theory considers fuzzy conditions and can handle fuzzy situations.

Definition 3. TFNs can be defined as a set of numbers within a grey system. For example, the rating of criteria and alternatives in this study are described by TFNs. The numerical interval contains uncertain information, and the TFNs are defined as $\otimes G, (\otimes G = G\Big|_{\underline{\mu}}^{\overline{\mu}})$. The lower and upper limit of G can be estimated, and G is defined as a lower limit TFNs.

$$\begin{cases} \otimes G = [\underline{G}, \infty) \\ \otimes G = (-\infty, \overline{G}] \end{cases} \tag{3}$$

Definition 4. The lower and upper limits of G can be estimated, and G was defined as an interval TFNs.

$$\otimes G = [\underline{G}, \overline{G}] \tag{4}$$

A set of TFNs is an operation based on sets of intervals rather than real numbers. In this study, the exact range of the corresponding operation was located on the interval

$\otimes G = [\underline{G}_1, \overline{G}_1]$ and $\otimes G = [\underline{G}_2, \overline{G}_2]$. Only the proofs of addition and subtraction were employed.

$$\begin{cases} \otimes G_1 + \otimes G_2 = [\underline{G}_1 + \underline{G}_2, \overline{G}_1 + \overline{G}_2] \\ \otimes G_1 - \otimes G_2 = [\underline{G}_1 - \underline{G}_2, \overline{G}_1 - \overline{G}_2] \end{cases} \quad (5)$$

Definition 5. The length of TFNs $\otimes G$ was defined as:

$$L(\otimes G) = [\underline{G} - \overline{G}] \quad (6)$$

Definition 6. For the two set of TFNs $\otimes G_1 = [\underline{G}_1, \overline{G}_1]$ and $\otimes G_2 = [\underline{G}_2, \overline{G}_2]$, the possible degree of $\otimes G_1 \le \otimes G_2$ was expressed as:

$$P\{ \otimes G_1 \le \otimes G_2 \} = \frac{\max(0, L^* - \max(0, \overline{G}_1 - \underline{G}_2))}{L^*} \quad (7)$$

where $L^* = L(\otimes G_1) + L(\otimes G_2)$. The positive relationship between $\otimes G_1$ and $\otimes G_2$ was determined as follows:

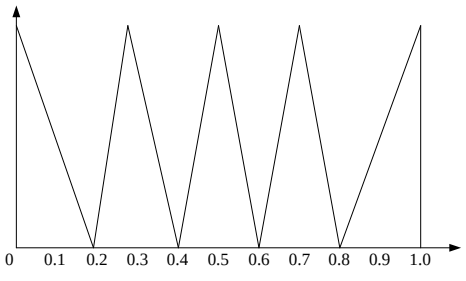
1. If $\underline{G}_1 = \underline{G}_2$ and $\overline{G}_1 = \overline{G}_2$, that $\otimes G_1 = \otimes G_2$, then $P\{\otimes G_1 \le \otimes G_2\}$ = 0.5
2. If $\underline{G}_2 > \overline{G}_1$, that $\otimes G_2 > \otimes G_1$, then $P\{\otimes G_1 \le \otimes G_2\}$ = 1
3. If $\overline{G}_2 < \underline{G}_1$ and $\overline{G}_1 > \overline{G}_2$, that $\otimes G_2 < \otimes G_1$, then $P\{\otimes G_1 \le \otimes G_2\}$ = 0
4. If $\otimes G_1$ and $\otimes G_2$ overlap, and $P\{\otimes G_1 \le \otimes G_2\}$ > 0.5, then $\otimes G_2 > \otimes G_1$. If $P\{\otimes G_1 \le \otimes G_2\}$ < 0.5, then $\otimes G_2 < \otimes G_1$.

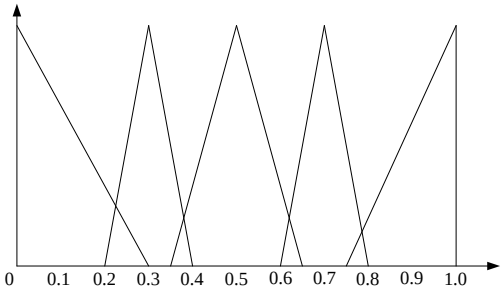
Proposed approach

In this study, fuzzy set theory and grey possible degree were applied to the evaluation of GSCM criteria. The objective of the study was to evaluate the application of fuzzy grey degree to the determination of GSCM criteria. To rank the suitability of the alternatives, grey theory was applied. In the proposed model, A = {A_1, A_2, …. A_m} is a discrete set of m possible alternatives, and C = {C_1, C_2,….C_n}is a set of n criteria and $\otimes w = \{\otimes w_1, \otimes w_2, \ldots\ldots\ldots, \otimes w_n\}$ is the vector of criteria weights. The weights and ratings of the alternatives were numbers located on the aforementioned interval scale. The procedures used to determine the optimal supplier are summarized as follows:

Step1. The fuzzy set theory was applied to determine the linguistic preferences of the proposed model. To this end, linguistic variables were defined for several levels of preference (Table 1). The TFNs used to represent the preferences are depicted in Fig. 2.

Table 1: Two linguistic variables for criteria and alternatives (importance and performance level).





(Criteria)	TFNs $\otimes G$	(Alternative)	TFNs $\otimes w$
VL	(0.00, 0.00, 0.20)	VP	(0.00, 0.00, 0.30)
L	(0.20, 0.30, 0.40)	P	(0.20, 0.30, 0.40)
M	(0.40, 0.50, 0.60)	F	(0.35, 0.50, 0.65)
H	(0.60, 0.70, 0.80)	G	(0.60, 0.70, 0.80)
VH	(0.80, 1.00, 1.00)	VG	(0.75, 1.00, 1.00)

A fuzzy weighted sum performance matrix (P) was derived for the criteria by multiplying the fuzzy weight vector by the decision matrix.

$$p = \left[\begin{pmatrix} a_1 & ,b_1 & ,c_1 \\ \dots & \dots & \dots \\ a_n & ,b_n & ,c_n \end{pmatrix} \right] \tag{8}$$

where *n* represents the number of criteria.

Step 2. Defuzzification. Defuzzification was conducted according to the method of Pan (2008); thus, TFN were used to transform the total weighted performance matrices into interval performance matrices, providing α_a and α_c for each criterion:

$$p_\alpha = \left[\begin{pmatrix} \alpha_{a1} & \alpha_{b1} & ,\alpha_{c1} \\ \dots & \dots. & \dots \\ \alpha_{an} & \alpha_{bn} & ,\alpha_{cn} \end{pmatrix} \right] \tag{9}$$

where *n* is the number of criteria.

$$\begin{cases} \alpha_a = \alpha \times (b-a) + a \\ \alpha_c = c - \alpha \times (c-b) \end{cases} \quad (10)$$

The last step of the defuzzification process was to convert interval matrices into crisp values by applying the Lambda function, which represents the attitude of the evaluator. Evaluators with optimistic, moderate and pessimistic attitudes take on maximum, intermediate or minimum Lambda values on the interval [0, 1], respectively:

$$W_j = \begin{pmatrix} W_j^1 \\ W_j^2 \\ ..... \\ W_j^k \end{pmatrix} \quad (11)$$

$$W_j = \lambda \times \alpha_c + (1-\lambda) \times \alpha_b$$

where W_j are crisp values corresponding to Lambda, λ=0.5, and were normalized to comparable scales.

Step 3. TFNs were used to obtain a rating of each criterion. The value of each rating was obtained from the following expression:

$$\otimes w_j = \frac{1}{K}\left[\otimes w_j^1 + \otimes w_j^2 + ... + \otimes w_j^k\right] \quad (12)$$

where $\otimes w_j^k (j = 1,2,.....n)$ are the weights of the K[th] expert and can be described by the TFNs $\otimes w_j^k = [\underline{w}_j^k, \overline{w}_j^k]$.

$$\otimes G_{ij} = \frac{1}{K}\left[\otimes G_{ij}^1 + \otimes G_{ij}^2 + ... + \otimes G_{ij}^k\right] \quad (13)$$

where $\otimes G_{ij}^k (i = 1,2,.....m;\ j = 1,2,.....n)$ are the weights of the K[th] expert and can be

described by the TFNs $\otimes G_j^k = [\underline{G}_j^k, \overline{G}_j^k]$.

Each expert group contains K experts. The criteria weights, w_j, were obtained from the following procedure:

Step 4. Establish the grey decision matrix

$$D = \begin{bmatrix} \otimes G_{11} & \otimes G_{12} & .. & .. & \otimes G_{1n} \\ \otimes G_{21} & \otimes G_{22} & .. & .. & \otimes G_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \otimes G_{m1} & \otimes G_{m2} & .. & .. & \otimes G_{mn} \end{bmatrix}$$

(14)

where $\otimes G_{ij}$ are based on TFNs.

Step 5. Establish the normalized grey decision matrix

$$D^* = \begin{bmatrix} \otimes G^*_{11} & \otimes G^*_{12} & .. & .. & \otimes G^*_{1n} \\ \otimes G^*_{21} & \otimes G^*_{22} & .. & .. & \otimes G^*_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \otimes G^*_{m1} & \otimes G^*_{m2} & .. & .. & \otimes G^*_{mn} \end{bmatrix} \quad (15)$$

For a benefit criteria, $\otimes G_{ij}^*$ was expressed as $\otimes G_{ij}^* = \left[\frac{\underline{G}_{ij}}{G_j^{\max}}, \frac{\overline{G}_{ij}}{G_j^{\max}} \right]$,

$G_j^{\max} = \max_{1 \le i \le m} \left\{ \overline{G}_{ij} \right\}$. For other criteria, $\otimes G_{ij}^*$ was expressed as $\otimes G_{ij}^* = \left[\frac{G_j^{\min}}{\overline{G}_{ij}}, \frac{G_j^{\min}}{\underline{G}_{ij}} \right]$,

$G_j^{\min} = \min_{1 \le i \le m} \left\{ \underline{G}_{ij} \right\}$. Normalization was conducted to preserve the property that the range of normalized TFNs was located on the interval [0, 1]

Step 6. By considering the importance of each criterion, the weighted normalized grey decision matrix was established as:

$$D^{*}=\begin{bmatrix} \otimes V_{11} & \otimes V_{12} & .. & .. & \otimes V_{1n} \\ \otimes V_{21} & \otimes V_{22} & .. & .. & \otimes V_{2n} \\ .. & .. & .. & .. & .. \\ .. & .. & .. & .. & .. \\ \otimes V_{m1} & \otimes V_{m2} & .. & .. & \otimes V_{mn} \end{bmatrix} \quad (16)$$

where $\otimes V_{ij} = \otimes G_{ij}^{*} \times \otimes w_j$

Step 7. The ideal alternative was established as the reference alternative. Thus, for m possible alternative sets, A = {A_1, A_2 ,...., A_m}, the ideal referential alternative $A^{\max} = \left\{ \otimes G_1^{\max}, \otimes G_2^{\max}, ... \otimes G_n^{\max}, \right\}$ was obtained from the following expression:

$$A^{\max} = \left\{ \left\lfloor \max_{1\le i\le m} \underline{V_{i1}},\ \max_{1\le i\le m} \overline{V_{i1}} \right\rfloor \left\lfloor \max_{1\le i\le m} \underline{V_{i2}},\ \max_{1\le i\le m} \overline{V_{i2}} \right\rfloor ..... \left\lfloor \max_{1\le i\le m} \underline{V_{in}},\ \max_{1\le i\le m} \overline{V_{in}} \right\rfloor \right\} \quad (17)$$

Step 8. The grey degree between compared alternatives (A = {A_1, A_2, ... A_m}) and the ideal alternative (A^{max}) was calculated, and the alternatives were ranked according to suitability. As $P\left\{ A_i \le A^{\max} \right\}$ decreased, the rank of A_i increased.

$$P\left\{ A_i \le A^{\max} \right\} = \frac{1}{n} \sum_{j=1}^{n} p\left\{ \otimes V_{ij} \le \otimes G_j^{\max} \right\} \quad (18)$$

RESULTS

To illustrate the utility of the proposed evaluation method, the model was applied to an actual firm. In the case study, the firm continues to improve its manufacturing processes and faces the challenges of environmental management and SCM. To deal with the requirements of supplier selection, the firm must implement GSCM criteria from relevant environmental regulations. To this end, the firm created an expert team consisting of four professors, two vice presidents and four management professionals with extensive experience.

Case information

Due to the prosperity of the electronic consumer products and network market, a plant was built in Taiwan to produce IC substrates and IC packing fields, to meet consumer demands in 2010. Currently, the firm is the largest professional printed circuit board (PCB) and original equipment manufacturer (OEM) in Taiwan and is the fifth ranked producer in the world. To offer the best services, the firm is continuing to develop next generation technology, enhance their competitiveness and satisfy customer demands. Moreover, due to the rapid replacement rate of electronic products, the firm continues to develop green products and new green technologies to comply with customer requirements. For the firm to sustain in a competitive market, proper GSCM is essential.

The chief executive officer wants to understand the role of GSCM, especially in the green market. Therefore, to develop the firm's GSCM criteria, this assessment was presented to the expert group. By complying with the requirement outlined in RoHS and WEEE directives, the firm benefited from this evaluation by acquiring purchasing orders from the USA and the European Union. In the case study, the firm's four green suppliers were analyzed. The expert group identified an analytical and systematic method of evaluating the management procedures of the suppliers. To select the optimal supplier, the experts should adopt an evaluation method from the proposed criteria. The analysis outlined in this paper would provide recommendations to the firm and would be useful for efficient and effective GSCM implementation.

Empirical result

In this study, the eight proposed steps were followed to analyze the data provided by the experts. The analysis was based on four alternatives A_i = (i =1, 2, 3, 4) and 16 criteria Cj (j = 1, 2, 3,….,16), as shown in Fig. 1. According to Eq. (8), the weights of the criteria were obtained from the group of experts and are shown in Table 2. The weights of the four suppliers were

obtained from Eq. (9), and the results are shown in Table 3.

Table 2: Criterion important weights.

C_j	D 1	D 2	....	D 10		$\otimes w_j$		Weights	Ranking
C1	(0.00, 0.00, 0.20)	(0.60, 0.70, 0.80)	....	(0.40, 0.50, 0.60)	0.35	0.60	0.90	0.617	12
C2	(0.40, 0.50, 0.60)	(0.40, 0.50, 0.60)	....	(0.60, 0.70, 0.80)	0.50	0.60	0.90	0.667	9
C3	(0.40, 0.50, 0.60)	(0.60, 0.70, 0.80)	....	(0.40, 0.50, 0.60)	0.40	0.60	0.90	0.633	11
C4	(0.60, 0.70, 0.80)	(0.60, 0.70, 0.80)	....	(0.60, 0.70, 0.80)	0.60	0.65	0.80	0.683	8
C5	(0.60, 0.70, 0.80)	(0.80, 1.00, 1.00)	....	(0.60, 0.70, 0.80)	0.50	0.80	0.90	0.733	6
C6	(0.60, 0.70, 0.80)	(0.00, 0.00, 0.20)	....	(0.80, 1.00, 1.00)	0.40	0.65	0.80	0.617	12
C7	(0.80, 1.00, 1.00)	(0.80, 1.00, 1.00)	....	(0.80, 1.00, 1.00)	0.65	0.80	0.90	0.783	3
C8	(0.80, 1.00, 1.00)	(0.40, 0.50, 0.60)	....	(0.00, 0.00, 0.20)	0.50	0.60	0.70	0.600	13
C9	(0.40, 0.50, 0.60)	(0.80, 1.00, 1.00)	....	(0.60, 0.70, 0.80)	0.53	0.60	0.80	0.643	10
C10	(0.80, 1.00, 1.00)	(0.60, 0.70, 0.80)	....	(0.60, 0.70, 0.80)	0.50	0.80	0.90	0.733	6
C11	(0.40, 0.50, 0.60)	(0.80, 1.00, 1.00)	....	(0.80, 1.00, 1.00)	0.60	0.60	0.70	0.633	11
C12	(0.60, 0.70, 0.80)	(0.60, 0.70, 0.80)	....	(0.60, 0.70, 0.80)	0.70	0.75	0.85	0.767	4
C13	(0.40, 0.50, 0.60)	(0.40, 0.50, 0.60)	....	(0.40, 0.50, 0.60)	0.60	0.70	0.80	0.700	7
C14	(0.60, 0.70, 0.80)	(0.60, 0.70, 0.80)	....	(0.60, 0.70, 0.80)	0.70	0.80	0.90	0.800	2
C15	(0.60, 0.70, 0.80)	(0.40, 0.50, 0.60)	....	(0.40, 0.50, 0.60)	0.80	0.80	0.90	0.833	1
C16	(0.40, 0.50, 0.60)	(0.60, 0.70, 0.80)	....	(0.60, 0.70, 0.80)	0.70	0.70	0.85	0.750	5

Table 3: Four alternative performance weights under firm's GSCM criteria.

C_j / A_i		D 1	D 2	....	D10	$\otimes G_{ij}$		
C1	A1	(0.20, 0.30, 0.40)	(0.35, 0.50, 0.65)	....	(0.35, 0.50, 0.65)	0.55	0.65	0. 75
	A2	(0.35, 0.50, 0.65)	(0.35, 0.50, 0.65)	....	(0.20, 0.30, 0.40)	0.65	0.85	0.90
	A3	(0.60, 0.70, 0.80)	(0.20, 0.30, 0.40)	....	(0.60, 0.70, 0.80)	0.45	0.60	0.75
	A4	(0.75, 1.00, 1.00)	(0.35, 0.50, 0.65)	....	(0.35, 0.50, 0.65)	0.75	0.85	0.95
C2	A1	(0.60, 0.70, 0.80)	(0.20, 0.30, 0.40)	....	(0.35, 0.50, 0.65)	0.65	0.85	0.90
	A2	(0.20, 0.30, 0.40)	(0.60, 0.70, 0.80)	....	(0.20, 0.30, 0.40)	0.70	0.75	0.85
	A3	(0.75, 1.00, 1.00)	(0.20, 0.30, 0.40)	....	(0.35, 0.50, 0.65)	0.65	0.85	0.95
	A4	(0.75, 1.00, 1.00)	(0.20, 0.30, 0.40)	....	(0.75, 1.00, 1.00)	0.3	0.6	0.80

						5	5	
C3	A1	(0.75, 1.00, 1.00)	(0.35, 0.50, 0.65)	….	(0.35, 0.50, 0.65)	0.65	0.85	0.95
	A2	(0.35, 0.50, 0.65)	(0.75, 1.00, 1.00)	….	(0.35, 0.50, 0.65)	0.45	0.65	0.75
	A3	(0.35, 0.50, 0.65)	(0.35, 0.50, 0.65)	….	(0.35, 0.50, 0.65)	0.65	0.85	0.95
	A4	(0.75, 1.00, 1.00)	(0.35, 0.50, 0.65)	….	(0.35, 0.50, 0.65)	0.45	0.85	0.95
C4	A1	(0.75, 1.00, 1.00)	(0.20, 0.30, 0.40)	….	(0.60, 0.70, 0.80)	0.40	0.60	0.75
	A2	(0.20, 0.30, 0.40)	(0.35, 0.50, 0.65)	….	(0.60, 0.70, 0.80)	0.45	0.65	0.75
	A3	(0.75, 1.00, 1.00)	(0.35, 0.50, 0.65)	….	(0.20, 0.30, 0.40)	0.50	0.65	0.70
	A4	(0.20, 0.30, 0.40)	(0.75, 1.00, 1.00)	….	(0.60, 0.70, 0.80)	0.35	0.55	0.65
C5	A1	(0.75, 1.00, 1.00)	(0.20, 0.30, 0.40)	….	(0.60, 0.70, 0.80)	0.65	0.85	0.95
	A2	(0.60, 0.70, 0.80)	(0.60, 0.70, 0.80)	….	(0.20, 0.30, 0.40)	0.45	0.75	0.75
	A3	(0.20, 0.30, 0.40)	(0.75, 1.00, 1.00)	….	(0.75, 1.00, 1.00)	0.65	0.85	0.85
	A4	(0.60, 0.70, 0.80)	(0.35, 0.50, 0.65)	….	(0.35, 0.50, 0.65)	0.45	0.75	0.85
	…	…	…	…	…	…	…	….
	…	…	…	…	…	…	…	….
	…	…	…	…	…	…	…	….
	…	…	…	…	…	…	…	….
C16	A1	(0.75, 1.00, 1.00)	(0.60, 0.70, 0.80)	….	(0.20, 0.30, 0.40)	0.55	0.85	0.95
	A2	(0.60, 0.70, 0.80)	(0.20, 0.30, 0.40)	….	(0.35, 0.50, 0.65)	0.50	0.70	0.85
	A3	(0.35, 0.50, 0.65)	(0.35, 0.50, 0.65)	….	(0.60, 0.70, 0.80)	0.55	0.65	0.85
	A4	(0.20, 0.30, 0.40)	(0.35, 0.50, 0.65)	….	(0.60, 0.70, 0.80)	0.45	0.65	0.75

Step1. In step 1, the expert's opinions on linguistic preferences of performance measures were collected and transformed according to the TFN membership functions provided in Table 1. The six definitions used to apply the following computational steps are denoted in Eqs. (1) - (6)

Step 2. 16 criteria and four alternatives were measured in the TFN. The defuzzification process employed Eqs. (9) - (10). The TFN was applied to transform the total weighted performance matrices into interval performance matrices, providing α_a and α_c .Using Eq. (11), W_j was transformed into crisp values corresponding to Lambda values on comparable scales.

Step 3. Using Eq. (12) and (13), TFNs for the ratings were calculated to obtain the criteria rating value, and the results are presented in Table 2 ($\otimes w_j$) and 3 ($\otimes G_{ij}$). $\otimes w_j$ was defuzzified into the weights and ratings of each criteria.

Step 4. In step 4, the grey decision matrix of alternatives was established according to Eq. (14).

Step 5. The grey decision matrix was normalized according to Eq. (15), and the resulting grey normalized decision table is shown in Table 4.

Step 6. According to Eq. (16), the weighted normalized grey decision matrix was obtained, and the results are shown in Table 5.

Step 7. The ideal alternative, A^{max} (the reference alternative), was calculated according to Eq. (17), and values of [0.614, 1.000], [0.574, 0.971], [0.547, 0.936], [0.486, 0.864] were obtained.

Table 4: Grey normalized decision matrix.

	C1		C2		C3		C4		C5		C6		C7		C8		C9	
A 1	0.735	0.898	0.825	1.000	0.818	0.780	0.962	0.825	0.825	1.000	1.000	1.000	0.825	1.000	0.825	1.000	0.780	0.962
A 2	0.769	0.932	0.788	0.964	0.818	0.742	0.924	0.715	0.715	0.891	0.891	1.000	0.752	0.927	0.715	0.891	0.742	0.924
A 3	0.735	0.898	0.825	1.000	0.742	0.780	0.962	0.825	0.825	1.000	1.000	0.924	0.825	1.000	0.788	0.964	0.780	0.962
A 4	0.837	1.000	0.752	0.927	0.780	0.818	1.000	0.752	0.752	0.927	0.927	0.962	0.752	0.927	0.752	0.927	0.818	1.000

	C10		C11		C12		C13		C14		C15		C16	
A 1	0.735	0.898	0.825	1.000	0.625	0.818	0.962	0.825	0.825	1.000	1.000	0.737	0.825	1.000
A 2	0.769	0.932	0.788	0.964	0.818	0.742	0.924	0.715	0.715	0.891	0.891	1.000	0.752	0.927
A 3	0.735	0.898	0.825	1.000	0.742	0.780	0.962	0.752	0.825	1.000	1.000	0.924	0.805	1.000
A 4	0.837	1.000	0.752	0.927	0.780	0.818	1.000	0.745	0.752	0.925	0.826	0.962	0.752	0.927

Table 5: Grey weighted normalized decision matrix.

	C1		C2		C3		C4		C5		C6		C7		C8		C9	
A 1	0.593	0.879	0.636	0.943	0.607	0.907	0.544	0.836	0.636	0.943	0.607	0.907	0.546	0.838	0.657	0.965	0.755	0.962
A 2	0.620	0.912	0.552	0.840	0.580	0.874	0.544	0.836	0.580	0.874	0.526	0.808	0.520	0.805	0.655	0.831	0.654	0.924
A 3	0.593	0.879	0.636	0.943	0.607	0.907	0.493	0.772	0.636	0.943	0.580	0.874	0.546	0.838	0.745	0.855	0.585	0.962
A 4	0.675	0.979	0.580	0.874	0.553	0.841	0.518	0.804	0.580	0.874	0.553	0.841	0.573	0.871	0.652	0.755	0.836	0.952

	C10		C11		C12		C13		C14		C15		C16	
A 1	0.735	0.898	0.825	0.950	0.685	0.818	0.655	0.825	0.825	0.921	0.758	0.855	0.796	0.862
A 2	0.769	0.932	0.788	0.964	0.755	0.835	0.458	0.685	0.715	0.891	0.831	0.956	0.752	0.927
A 3	0.735	0.898	0.825	0.965	0.589	0.742	0.752	0.825	0.825	0.911	0.756	0.924	0.825	0.965
A 4	0.837	0.925	0.752	0.927	0.652	0.780	0.555	0.752	0.752	0.927	0.852	0.962	0.752	0.927

Step 8. The grey degree of the four alternatives, (A1, A2, A3, A4), was calculated from Eq. (18), and a ranking of the alternatives was obtained. The grey degrees of the alternatives were $P(A_1 \le A^{\max}) = 0.522$, $P(A_2 \le A^{\max}) = 0.555$, $P(A_3 \le A^{\max}) = 0.541$, $P(A_4 \le A^{\max}) = 0.552$. The smallest value indicates the best alternative; thus, A1 is the optimal supplier. Moreover, the following trend in suppliers was observed: A1>A3>A4>A2. Hence, to achieve the firm's GSCM criteria, supplier A1 is an important alternative.

MAMAGERIAL IMPLICATIONS

The framework can be used to evaluate the impact of various supplier selection activities and can provide a mechanism of monitoring and establishing evaluation platforms for firms in the green supply chain. In previous studies, the firm's GSCM procedures were highly variable; however, a clear link to the firm's decision was not observed. Indeed, the analyses presented in previous studies were based on only a few variables, and single variable models were not sufficient at explaining GSCM criteria. These results indicate that GSCM is a multi-criteria concept based on upstream or downstream selection in the supply chain. When evaluating the impact of a firm's GSCM activities, the overall enhancement in production and its effect on the organization must be considered.

By examining the 16 criteria, the proposed framework allows managers and researchers to better understand the differences in operations, activities and specific management interventions. The framework allows the firm to control and evaluate management practices and can describe the firm's supplier selection dilemmas. For example, in step 8, a value is placed on the overall importance of the evaluator's perception to the four alternatives. Here, the top five criteria and corresponding values were: 1. to reduce the use of hazardous products in the production process (C15- 0.833); 2. support of management (C14- 0.800); 3. quality of service (C7- 0.783); 4. the applicability of internal green production plans (C12- 0.767); 5. the presence of environmental management systems (C16- 0.750). The GSCM criteria were analyzed by the experts, and the performance of the supplier was determined primarily by the reduction of hazardous products in the production process and management support.

The results of the case study are similar to those of Yao et al. (2007), who found that management support and external influences are important determinants. Moreover, perceived benefits to customers or suppliers, and internal benefits affect the use of electronically-enabled supply chains. Tseng et al. (2009a) studied sustainable production indicators, and found that two major criteria contributed to sustainable production, including a reduction in waste generated by contracted service/material providers and a

reduction in the amount of hazardous waste generated by the supplier. In a broader sense, the framework can be used as an analytical tool to develop and construct a strategic environmental development plan and GSCM criteria for the firm. To achieve optimal results, managers should understand the firm's GSCM evaluation criteria, including the presence of linguistic preferences and incomplete information.

This study proved that the manager must be aware that the firm's GSCM is not just a black box. Through the proposed framework, managers are able to capture a fairly complete picture of the firm's GSCM. In other words, managers may find that the proposed framework for the assessment of GSCM criteria is a useful method for reviewing and improving strategic development plans and performance evaluations, which may lead to enhanced productivity and competitive advantage.

For firms that intend to evaluate suppliers with the proposed criteria, this study offers several benefits. The main contribution of this study is the hierarchical model presented in Fig. 1. This model provides a structured and logical method of synthesizing judgments that can be used for the evaluation of appropriate suppliers. The model is a useful guideline that helps structure a difficult and often emotional decision. The second benefit of this study is the development of criteria based on a comprehensive review. Moreover, the features of a firm's GSCM have been examined and identified.

The model developed in this study provides an overview of a firm's decision-making process in the presence of incomplete information. Moreover, firms can better understand the evaluation criteria of GSCM by applying the proposed model. The methodology outlined in this study is particularly useful for making decisions based on multiple criteria in the presence of linguistic preferences and incomplete information. Moreover, the framework can be customized and used for the selection of suppliers and management activities. To apply the proposed methodology, the evaluator must remove irrelevant criteria and include criteria that are applicable to their firm. Thus, a firm's GSCM can be based on many different types of criteria and can be modified and refined as necessary.

Furthermore, this study proposed a hybrid MCDM for selecting alternatives in the presence of uncertainty. However, the evaluator's judgment is often uncertain, and incomplete information cannot always be evaluated with exact numbers. An empirical example of green supplier selection was used to illustrate the application of the proposed criteria in an OEM firm. The experimental results indicated that the proposed approach is reliable and reasonable, and an optimal alternative was selected from the four possible choices. The proposed model can easily and effectively accommodate validated criteria. The proposed

model establishes a foundation for future research and is appropriate for predicting uncertain criteria. To improve the firm's performance and provide information that will have the greatest effect on reducing uncertainty, a firm can apply this model to evaluate and determine the optimal GSCM supplier.

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H2 – Organizational learning and innovation

H2.1 **A comparative study of two communities of practice in a non-profit setting**
Dr. Li-An Ho

H2.2 **Organizational competency gap and methods of its reduction**
Agnieska Sitko-Lutek

H2.3 **Internal and external antecedents toward organizational learning and innovation: A conceptual framework**
Onwika Kaewchur

H2.4 **Leadership by trust for organizational innovativeness: Renewal of human intellectual capital in focus**
Prof. Taina Savolainen

H2.5 **Leader's untrustworthy behaviour decreases innovativeness of followers: What kind of leadership organizations need to assure their innovative development?**
Sari Häkkinen

A COMPARATIVE STUDY OF TWO COMMUNITIES OF PRACTICE IN A NON-PROFIT SETTING

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ABSTRACT

The present study aims to investigate the current status of two communities of practice: the network of knowledge chief managers (NKCM) of China Productivity Center (CPC) as well as iEARN Taiwan. The study adopts the qualitative method, using case studies to explore the development process of both communities. The data collection methods include documents analysis, file archives, observations as well as interviews. The results reveal that although the participants of both NKCM at CPC and iEARN Taiwan joined the communities for various personal interests, they all received organizational supports during their participations of community activities. However, the participants of CPC were more oriented toward the enhancement of professional development, cognitive interests, social relations, work improvement, organizational services, or marketing information collection. The participants of iEARN Taiwan were attracted to the community by exploring ways to improve their instructions as well as purpose sound instructional methods. The interactions for both communities were diverse and the content of interaction was broad. As for collaboration, the participants of iEARN Taiwan demonstrated higher motivation for collaboration than people in CPC group.

Keywords: community of practice, organizational learning, professional development

INTRODUCTION

In most corporate organizations, competitive advantages are characterized as people's tacit knowledge. As Kakabadse, Kouzmin and Kakabadse (2001) point out that knowledge, explicit or tacit, has emerged as one of the key strategic assets, although invisible, of organizations. It is obvious that tacit knowledge has integrated into people's daily conversations or life stories. Nowadays, even task skills can be disseminated in to daily dialogues or a work network, which makes it even more difficult to control, maintain or structuralize. Thus, Wenger (1998) suggests organizations begin to build up necessary policies and infrastructure in order to effectively manage knowledge, if organizations consider knowledge as one of their strategic assets.

Arther Anderson Business Consulting (1999), a well-known consulting company, points out that community of practice is an effective form to facilitate knowledge building. Cross, Parker, Prusak, and Borgatti (2003) believe that organizations may enhance networking for knowledge cooperation within organizations through various ways. Supporting community of practice appears to be one of the most effective ways for that effect.

The term, community of practice (CoP), was first introduced in 1991 by Lave and Wenger. According to Lave and Wenger (1991), CoP refers to a group of people have shared visions, questions or compassion through continuous activities. Their ultimate goal of people participating CoP is to acquire expert knowledge and obtain higher professional practices. Lave and Wenger claim that workers are part of social networks, in which they share their perceptions collaboratively. Also, the sharing process is dynamic rather than static. Thus, knowledge is not stored in each individual, but delivered and shared through interactions among individuals.

Since the recognition and popularization of community of practice, numerous studies have undertaken to explore its insights. However, considerate amount of researchers claim this area is a virgin territory waits to be explored, especially in the line of practical case studies. Compared to western literature, local studies lack documentations in regards to the development and implementation of community of practice. Consequently, the present study aims to investigate the current status of two communities of practice in a non-profit setting. They are the network of knowledge chief managers (NKCM) of China Productivity Center (CPC) as well as International Education and Resource Network (iEARN) Taiwan. A qualitative research method was used. By understanding the two cases, the present study aims to answer the following questions:

1. Why do people join a community of practice? (Motivation)
   Is there any difference between the members in the two communities of practice in terms of their motivation to participate in community activities?
2. How do communities of practice function? (Implementation)
   Is there any difference between the two communities of practice in terms of the members' interaction/communication, cooperation/collaboration and the organizational resource/support they receive?
3. What are the outcomes of communities of practice? (Outcome)
   Is there any difference between the two communities of practice in terms of advantages, disadvantages or challenges?

THEORETICAL FOUNDATION

The definition and scope of CoP

Since Lave and Wenger, the parent of CoP, in their book "situated learning: legitimate peripheral participation", first introduced the concept of community of practice, it has been the focus of attention (1991). According to them, CoP is defined a group of people who share interests, crafts and/or professions. The group may develop naturally resulting from the join members' common interests in a particular domain, or it can be created specifically with a purpose of advancing knowledge in a particular domain or field. Through the processes of information sharing and experience exchanging, the members of CoP are given the opportunity to develop themselves personally as well as professional. Hildreth and Kimble (2004) further point out that CoP is not only a theory of learning but plays an important role in the field of knowledge management. CoPs can be implemented through actual contacts, such as in a conference room at work, or via online mechanism, such as through discussion boards and newsgroups.

CoP can exist in various forms in terms of size of the group, duration of community, homogeneity or heterogeneity, Wenger (1998) suggests that CoP is examined through three levels: what it is about? How it functions? What capability it has produced. Wenger further addresses three elements that constitute a CoP. There are community, domain and practice, and suggests the successful implementation of a CoP involves mutual engagement, joint enterprose, and shared repertoire. Similar to Wenger's concept, Brown and Duguid (1991) propose that a CoP consists of three components: narratives, collaboration, and social constructivism. In other words, organizations depend on these informal relationships among groups to share and validate organizational knowledge. Through the processes of individual negotiation of meaning and insight and narratives sharing, organizational knowledge may evolve and become mature.

The development process of CoP

CoP exists in any organization. According to Wenger (1998), CoP is not bound by organizational affiliations, thus can be found (1) within businesses, (2) across business units, and across company boundaries. In addition, similar to team developmental process, CoP also move through various developmental stages which are characterized by different levels of interaction among members and by different kinds of activities. According to Wenger (1998), there are five stages in the CoP development process, namely potential, coalescing, active, dispersed and memorable stages (see Figure 1).

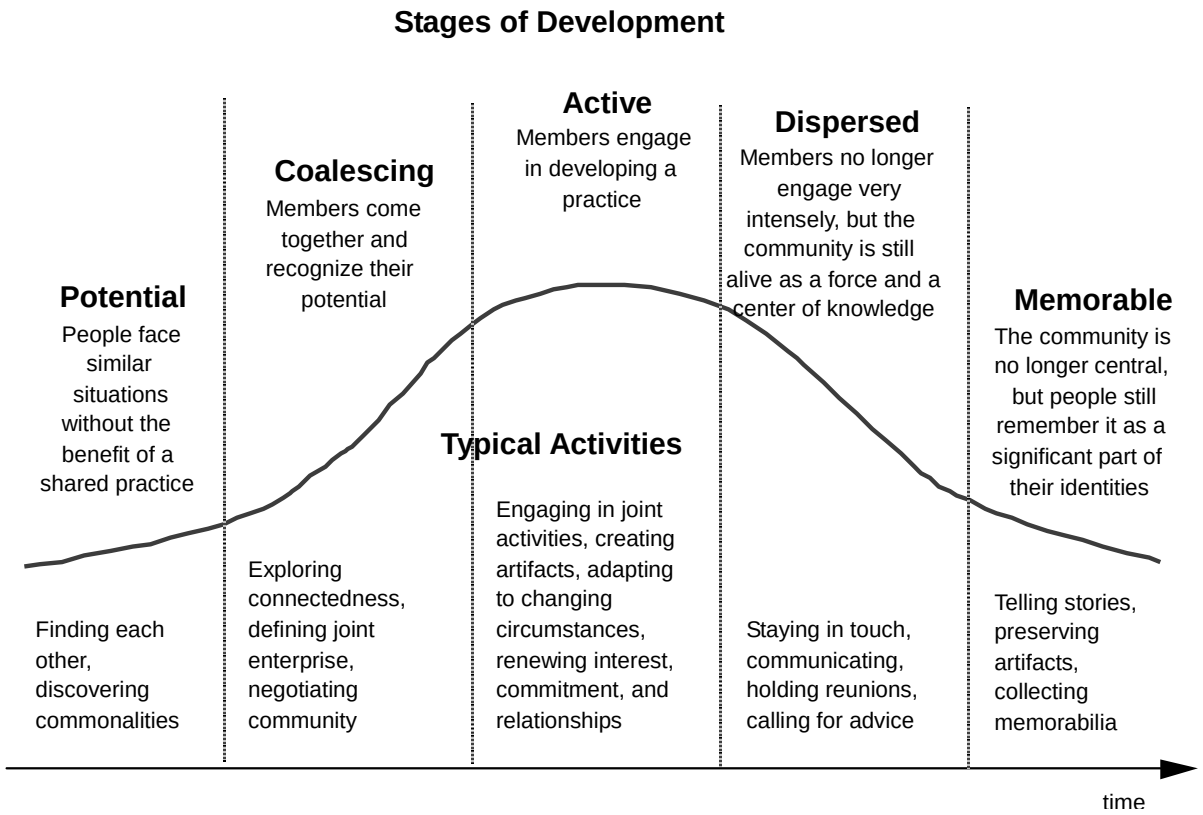

Figure 1: Stages of development for CoP (Wenger, 1998, p. 3).

Wenger, McDermott, and Snyder (2002) further conclude CoP very much like a living system which goes through a life cycle of born and dead. They divide the developmental process of CoP into five stages, including potential, coalescing, maturing stewardship, and transformation. Moreover, based on their IBM global experience, Gongla and Rizzuto (2001) propose a similar yet different view of CoP stages of development. Their study also divide the CoP development process into five stages which characterized different functions. Stage one is the potential stage, in which a CoP begins its formation and the main function is connection. Stage two is building in which community norms are established and the main function is memory and context creation. Stage three is engage, in which a CoP stabilizes and the maim function is access and learning. Stage four is active in which community members begin to understand and prove their values through knowledge management and community tasks and the main function is collaboration. The final stage is adaptive, in which communities and supporting organizations sustain their competitive advantages through knowledge development and the main function is innovation and generation. Gongla and Rizzuto further point out not all CoP move through all five stages of development. Most CoPs stay at stage three, engage stage; few enter stage four and none found in stage five.

The outcomes of CoP

Wenger, McDermott, and Snyder (2002) believe that CoP is the key for organizations to be successful in knowledge economy. Wenger, McDermott, and Snyder (2000) suggest CoP can "drive strategy, generate new lines of business, solve problems, promote the spread of best practice, develop people's skills, and help companies recruit and retain talent" (p. 105). According to Allee (2000), CoPs are beneficial for the business, for the community itself, and for employees (see Table 1 for details).

Table 1: Benefits of communities of practices (Allee, 2000, p. 8).

Categories	Benefits
Business	● Help drive strategy ● Support faster problem solving both locally and organization wide ● Aid in developing, recruiting and retaining talent ● Building core capabilities and knowledge competencies ● More rapid diffuse practices for operational excellence ● Cross fertilize ideas and increase opportunities for innovation
Community	● Help build common language, methods, and models around specific competencies ● Embed knowledge and expertise in a larger population ● Aid retention of knowledge when employees leave the company ● Increase access to expertise across the company ● Provide a means to share power and influence with the formal perts of the organization
Individual	● Help people do their jobs ● Provide s stable sense of community with other internal colleagues and with the company ● Foster a learning-focused sense of identity ● Help develop individual skills and competencies ● Help a knowledge worker stay current ● Provide challenges and opportunities to contribute

METHOD

Research Method and Research Structure

This study adopts a qualitative research method (i.e. case studies). The data collection methods include document analysis, observations, and interviews. Figure 2 presents the research structure for the present study.

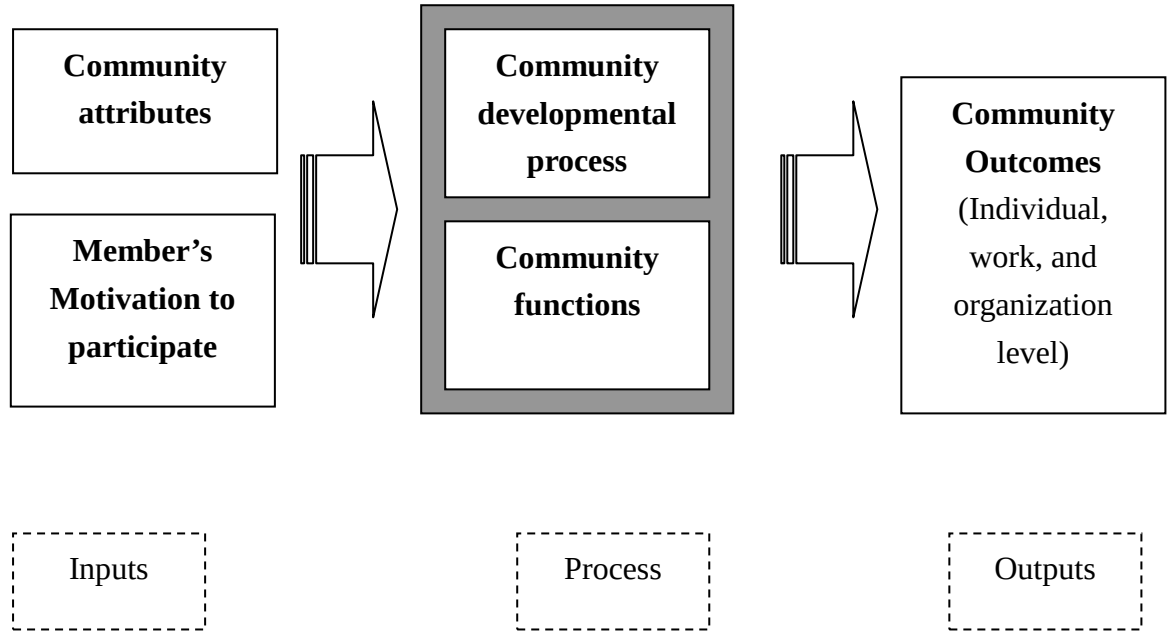

Figure 1: Research structure.

The Two Sample Cases

This study aims to explore two CoPs in a non-profit setting. The following briefly introduce the two sample cases: the network of knowledge chief managers (NKCM) of China Productivity Center (CPC) and International Education and Resource Network (iEARN) Taiwan.

First of all, iEARN is a non-profit organization made up of over 30,000 schools and youth organizations in more than 130 countries. iEARN empowers teachers and young people to work together online using the Internet and other new communications technologies. Over 2,000,000 students each day are engaged in collaborative project work worldwide. Since 1988, iEARN has pioneered on-line school linkages to enable students to engage in meaningful educational projects with peers in their countries and around the world. Additionally, iEARN offers both face-to-face workshops and online professional development

courses for educators seeking to integrate online global project work into their classrooms. Since 1988, iEARN has equipped more than 100,000 educators with the technical, collaborative and organizational skills needed to participate fully in a global, collaborative Internet-based learning environment.

Established in 2001, iEARN-Taiwan is a local chapter of iEARN, which works in conjunction with the Ministry of Education in Taiwan and the Taiwan Academic Network (TANet). iEARN-Taiwan provides local educators and students an opportunity to work on projects together using the Internet and other new communications technologies. Up till now, there are thirty local schools become the members of iEARN-Taiwan and the accumulated number of participating teachers and students has exceeded 3,000.

The network of knowledge chief managers (NKCM) is a group under the supervision of Taiwan's Industrial Development Bureau from Ministry of Economic Affairs (the controlling government agency). Since the Taiwan's government recognizes the trend of knowledge economy, the Industrial Development Bureau has made a series of plans (or stages) to facilitate organizations establishing their knowledge management mechanism since 2002. The NKCM was included in the action plan of the second stage. China Productivity Center (CPC) was designated to be the organizing unit of NKCM and has tried to recruit knowledge chief managers from various businesses in different industries to join the community. It is hoped that these knowledge chief managers can discuss their experience and knowledge in the area of knowledge management through real-life activities and online interactions.

Tested in 2006 and formed in 2007, the primary members of NKCM are from companies that received counseling from Industrial Development Bureau and technology service providing entrepreneurs. NKCM is a non-profit community which aims to provide a cross function interactive platform in order to promote national awareness of knowledge management, to facilitate interaction and collaboration of knowledge management practices, and direct the national trend of knowledge learning. A committee for NKCM was formed to discuss the constitutions of this community and roll out community activities.

Research Participants

This study adopts purpose sampling in conjunction with snowball sampling to recruit participants. A total of 28 participants, 16 from iEARN-Taiwan and 12 from NKCM, were invited for interviews. Triangulation and members check were used to improve the reliability and validity of our data.

RESULTS

The following present the similarities and differences between i-EARN Taiwan and NKCM based on our data (read table 2 to table 4).

Motivation

Table 2: The comparison of members' motivations to participate in a CoP.

	iEARN Taiwan	NKCM
Similarities	● Common interests (project-based learning) ● School's support and encouragement	● Personal interests (knowledge learning and management) ● Company's expectations
Differences	● An extension of personal educational concepts ● To emulate those better than oneself ● Broaden educational territory (or boundary)	● Professional development ● Accumulate social network ● Work Performance improvement ● Devote to organizational services ● Gather market information

Interaction

Table 3: The comparison of the interactions between the 2 groups.

	iEARN Taiwan	NKCM
Similarities	● They are a number of ways for its community members to interact (e.g. seminars, field trips, lectures, online discussion forum, etc) ● The content of communication is diverse. ● Members received high level of employers' support to participate community activities.	
Differences	● The collaboration level among member is comparatively high	● The collaboration level among member is comparatively low

Outcome

Table 4: The comparison of the outcomes between the 2 groups.

	iEARN Taiwan	NKCM
Similarities	● A common language in the field is built. ● Enhance knowledge sharing in a positive way ● Provide opportunities to learn ● Provide access to information ● Facilitate personal professional growth ● Broaden personal views ● Establish and accumulate social relations (networking)	
Differences	● Improve non-instructional abilities ● Accumulate project outcomes, which is useful for getting a job or getting in a school for future studies ● Improve teaching effectiveness ● Improve student learning outcome, especially in language	● Solving KM related problems at work ● Improve work procedure for better practice ● Strengthen KM field ability ● Provide consulting opportunities ● Provide business opportunities ● Getting help on product positioning

	and learning attitude ● enhance student learning motivation ● Students learn to share, appreciate, collaborate, and giving feedback	strategy ● Help implement KM platform ● Help set up KM related policies

CONCLUSION

The present study aims to investigate the current status of two communities of practice in a non-profit setting. The study analyzes two CoPs: NKCM as well as iEARN Taiwan. A qualitative research method was used to learn how the two communities different in three ways: motivation, interaction, and outcome.

First of all, the study learns that even people join a community due to personal interests or goals (agenda), more importantly; organizational support is a key issue for people to continuously participate in community activities in a long run.

Secondly, both communities appear to utilize various activities to enhance members' interactions. Both adopt face to face as well as online methods, although one may favor one of the methods over the other due to actual constrains (e.g. Geographical positions of members). The content of interaction shows freedom. It is not limited by the organizing unit of the communities. Community members demonstrate high level of enthusiasm on sharing knowledge. iEARN Taiwan shows a higher level of collaboration due to there were actual projects to be selected and to be worked on.

Finally, the study also finds both communities present positive outcomes not only on a community level, but also on an individual, work, and organizational level. Both communities were able to form a shared learning space using a common (shared) language in their particular field. Both communities turn knowledge learning into a positive force to help members to broaden their views and to develop professionally.

Based on our findings, all community members perceived CoP positively and were impressed with the outcomes from community activities. CoP demonstrates once again positive practices which bring many unexpected benefits which we think are worth further pursuit.

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ORGANIZATIONAL COMPETENCY GAP AND METHODS OF ITS REDUCTION

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ABSTRACT

Organisational competences have become a major factor in gaining the competitive advantage. There is no consensus regarding the definition of this term, yet it is possible to determine the most popular attitudes presented in professional literature: the first perspective treats organisational competences in the context of the employees' own competences, whereas the second one focuses on the competitive advantage. Within the research perspective of competences, the following tendencies will be presented: resource-based, evolutionary, dynamic abilities-based, that of competence-based competition and a knowledge-based theory. The paper discusses the essence of organisational competency gap identifying the concept and methods of reducing it as well as the effectiveness perspective

The methods of reduction organisational competency gap will be discussed. The process of competency management through organisational learning is discussed.

The study also presents the results of quantitative research carried out in 56 Polish enterprises.

A description of the methods and procedures of competency gap management may significantly contribute to developing effectiveness of organization.

The present article aims at:

1) *presenting different views concerning organizational competencies,*
2) *suggesting a classification of competency gaps and the methods of their reduction,*
3) *presenting the results of empirical studies concerning the frequency of using particular methods of reducing competency gaps in different enterprises,*
4) *pointing at the practical implications of the discussed problem,*

Keywords: competency, organizational competency, organizational competency gap,

INTRODUCTION

In order to achieve a permanent competitive advantage in the changeable and complex global environment the functioning of organizations must be based on their effective application of the tangible and intangible resources they possess.

The results of scientific research concerning the sources of success and failure experienced by different enterprises suggest that internal factors, such as corporate culture, organizational structure, management systems, resources or abilities have a much more significant effect on the quality of company's functioning than the changes occurring in the environment.

One of the most vital determinants of the organization's successful functioning is its competences. They may be understood as a synthesis of resources and organizational abilities. Such competences are inherent in the processes, systems and structures of a particular organization and they are adopted by all or the vast majority of its members. The competences understood in this way remain an element of the organization even when its individual employees are leaving. Organizational competences are mainly based on routine activities which account for the fundamental organizational system of storing knowledge and establishing patterns of conduct.

There is usually a divergence between the competences of an enterprise and those that are necessary to accomplish its goals. It is defined as competency gap. There are different types of competency gap: current, anticipated, objectivized, perceptive, partial or total gap.

To function effectively, it is necessary for an enterprise to identify immediately competency gaps as soon as they occur, to assess and to eliminate them successfully. The reduction of competency gaps may be implemented with the help of the following procedures: acquiring tangible resources, acquiring financial resources, introducing elements of knowledge management, finding experts on the job market, acquiring competences from a business partner, collaborating with consulting companies, co-operating with scientific and research institutions, training courses (internal and external), learning in action, learning from rival companies and outsourcing.

The source of knowledge which made it possible to work on the present article was provided by the studied literature and empirical analyses.

Studying the literature on economics and sciences concerning organizations and management included the review, comparison and systematization of the definitions of the terms that were vital from the point of view of the issues discussed here, namely organizational competency, competency gap and the methods of its reduction. This led to adopting the definitions of the terms such as "organizational competencies" and "competency gap" that are used in the present work. It also provided a basis for developing the tools used for performing empirical studies.

The empirical research had also a quantitative character. It was conducted with the use of questionnaires in 56 enterprises that that had been intentionally selected. The aim of the study was to analyze and assess the determinants and frequency of choosing particular methods of reducing competency gap in the analyzed companies.

On the basis of literature studies it was stated that the issue of organizational competency was not new, as it was discussed already in the reference books published in the 1950s. However, it has not been fully recognized yet. The reason may be the fact that the structure of organizational competency was gradually evolving during the last few dozens of years.

The share of intangible assets was increasing while the significance of tangible and financial assets was diminishing.
The analysis of the existing knowledge on competency gap suggests that the issue has been the subject of a single research project so far. Thus, it may be treated as a *novum*.

THE RESEARCH PERSPECTIVE OF COMPETENCES

A belief that internal, knowledge-based resources play a significant role in acquiring and maintaining the company's competitive advantage finds an increasing number of supporters in the global environment. Such resources are known as organisational competences, although the term is not precisely defined. Managers and scientists have a rather vague idea of what it really means, yet both groups perceive competences as a decisive factor in reaching success in the contemporary economic system.

The term "competences" can be used in different meanings. Its manifold interpretations result from a large number of subjects to which it is referred, e.g. managers, human resources, organisations, as well as from different areas of interest in these issues, deriving from strategic management, quality management or human resource management.

The professional literature is dominated by two approaches concerning the analysis and description of organisational competences. The first approach treats organisational competences in the context of the competences of its employees. Individual competences of the staff create the potential of work, whereas the individual potential of an employee is composed of their abilities, health, knowledge, practical skills, moral level and motivation, all of which is their competences. Thus the competence potential of an organisation is the product of individual work potentials, expressed in the number of the employees and individual working time.

The other, more extensive, approach concerns the company's competitive advantage on the market, and the key issue here is the organisational competences. These are made of such elements as the unique, specific know-how and jointly created experience and abilities of the organisation which have contributed to its competitive advantage. Organisational competences often provide foundations for building its future strategy.

The latter approach has produced works referring to the role of competences, reflected in the dynamic development of a particular research approach known as the competence-based perspective. The advocates of this attitude focus primarily on analysing the organisation's interior, trying to find there the sources of its competitive advantage. They emphasise the heterogeneous character of the organisation's components and see the opportunity of gaining the competitive advantage in its unique composition of resources and talents which make it possible to receive some regular income on the basis of the competences possessed (Wernerfelt, B., 1984).

The competence perspective includes a series of theoretical models presenting the meaning of competence in gaining and maintaining an advantage over one's competitors (Escrig-Tena, A. B. and Bou-Llusar, J. C., 2005). It is derived from classical works by P. Selznic (1957) and E.T. Penrose (1959) discussing strategic management. The authors see an organisation

as a set of diverse resources, able to fully explain the differences between competitive positions taken in practice by particular companies.

The competitive perspective also includes the so-called resource-based view which is expressed by B. Wernerfelt, Y.Dierickx, K. Cool, R.M. Grant, J.B. Barney and others. This approach focuses on examining the properties, abilities and resources which are at the company's disposal and enable it to gain and maintain a permanent competitive position on the market.

Another component of the competence perspective is the so-called evolutionary perspective presented e.g. by R. Nelson and S.G. Winter in their studies. This attitude concentrates on examining the method used by a company to adapt itself to the environment and the changes that occur in it through trying to find randomly new, more advantageous procedures and routines.

The competence perspective also involves the so-called *dynamic capability theory* formulated by D.J. Theece and G. Pisano. This concept stresses the special, strategic meaning (the principles of superior order) of the ability to acquire, build and re-configure the competences that are present both inside and outside the organisation, which are necessary to adjust the latter to the dramatically changing environment.

On the other hand, the *competency-based competition* whose supporters include, among others, C.K. Prahalad, G. Hamel, R. Sanchez, N.J. Foss and S.G. Winter focuses on analysing such resources and abilities which make it possible to maintain the competitive advantage, as well as on the processes of acquiring and developing competences.

Finally, there is the *knowledge-based theory,* represented by B. Kogut, U. Zander, G.A. Hedlund, I. Nonaka and H. Takeuchi, which treats organisations as heterogeneous entities characterised by a unique composition of basic organisational knowledge.

The competence perspective, though promising as a platform of theory creation, still has not developed any adequate methods of how to make the theoretical constructs it uses operational. What is particularly bothersome, is a lack of objective standards which could measure organisation's resources and competences in a situation where all traditional indices based on the data from the sphere of finance and accountancy prove to be completely useless.

A common assumption underlying the competence perspective is giving the major role to the resources and competences which are unique to an individual organisation and based on the knowledge (mainly hidden), hard to communicate and distributed among the members of a given firm.

Organisational core competences

Since the beginning of the 1990s the popularity of the idea of organisation's core competences has been increasing. The concept was developed in strategic management within the resource approach. Unlike in the classical approach, where the source of the

company's success is considered to be its ability to adapt to external conditionings, the resource perspective emphasises the success factors inherent in the organisation itself. According to G. Gierszewska (2005), the most popular works in this area include the concepts of *core capabilities* by G. Stalk, P. Evans and L.E. Shulman, *core competences* by G. Hamel and C.K. Prahalad and *distinctive competences*.

G. Hamel and C.K. Prahalad (1994) introduced the idea of organisational competences which they defined as *„a unique combination of the business' specialisation and human abilities which reflect the organisation's typical character (…), the areas of knowledge and experience characteristic of a particular company"*. Since they affect the area of a business's competitive advantage, they were given the name of core competences.

Core competences are developed in the process of corporate learning. Learning and competences are mutually related. The learning process depends on the character of a company and involves collecting specific resources, skills and experiences and transmitting them onto new products and processes.

The process of core competence building is initiated by accumulating and exchanging information which may come from the knowledge generated in the company or from learning in action, in practice. The experience acquired results in developing an individual, unique for a given organisation, path of technical skill improvement and learning abilities. The information which has been acquired, stored and made available provides a basis to build the company's universal and hidden knowledge.
The next stage of core competence development is „experimenting". This means that the continuous improvement of the existing abilities and striving for more effective incorporating of new technologies enhance a certain creativity potential, which helps the company overcome its internal inertia and maintain its development impetus.

The final stage is constructing *dynamic routines* playing an important role in fostering new abilities and skills. The way the company supports dynamic routines of activities and learning inside and between organisational entities significantly influences the extent to which skills and abilities become rooted in the general social awareness of the organisation. In time, core competences become formalised and thus make a part of the world's system of knowledge creating. Having been fixed in the firm's social structure, competences become the sources of its competitive advantage.

The authors compare an organisation to a tree whose roots and stabilisers are made by competences, the role of the trunk is assumed by core products and these result in a system of business units which, in turn, bring about final products. However, just watching the final products is not enough to assess adequately the strength of the rivals. Core products make links between core competences and final products, a physical form of one or more core competences. Distinguishing core competences, core products and final products is vital, as each level is characterised by different principles of competing and the company may have a different market share in each of the areas. In order to build and maintain a competitive advantage for a long period of time the company should be the leader on each of the mentioned levels.

The most relevant features of core competences are listed by G. Gierszewska as (2005. pp.33-34):

- „invisibility", or remaining hard to be identified by competitors, e.g. through the techniques of benchmarking,
- being difficult to be imitated for competitors
- lack of substitutes
- durability, or building the enterprise's success and its development in a long time span, life cycle longer than that of ordinary competences,
- advantage over rivals' competences,
- making it possible to enter many different markets,
- ensuring cooperation with clients.

It is emphasised that core competences of a business are built on the basis of unique relationships between the resources, skills, strategy, goals, culture, management structure and methods, which makes them so difficult to be imitated by competitors. This, in turn, equips the company with a significant strategic power and increasing competitiveness, especially in the environment of global economy and quick technical advancement.

Imitating core competences is tough and requires that the copying one should perform the same set of „irreversible" investments and training. The organisation's competences are frequently impossible to copy, since the technology, learning process and skills are specific for the context of their development, used outside the company and may have no or hardly any value for the competitors. The particular "irreversibility" of the investment also leads to a certain dependence on the chosen path on which the existing strategy and method of organising the company result from its rare resources, business understanding and resources accumulated over a longer period of time, yet on the other hand they affect the evolution of skills and strategic opportunities in the future.
One step ahead is made in J. Kay's concept which is an expansion of the work by G. Stalk, P. Evans and L.E. Shulman. According to J. Kay (1996, pp. 99-102), core competences are: the ability to transform competences into specific benefits for the client, where the basic abilities of the company include architecture (internal and external relationships of the company with its employees, clients, suppliers and competitors), reputation (clients' opinion about the enterprise), innovations (product improvement, using more economic techniques and technologies) and strategic assets (natural monopoly, exclusive rights, irreversible costs).

A comprehensive analysis of core competences was performed by R.M. Grant and M. Javidan. They developed a model of "core competences" presenting the relationships between resources, abilities, competences and core competences. The lowest level is occupied by are material and non-material resources as the elements contributing to the chain of values yet are characterised by relatively lowest value for the enterprise. Among non-material assets eight basic categories were distinguished, related to technology, building a liaison with the client, methods of reaching an agreement, data processing (e.g. specialist software), human assets, marketing, company's location and goodwill. The level of making use of the resources, which at the same time determines the potential of a particular organisation, was called its abilities, whereas competences make a set of abilities

combined with know-how, and are a result of organising and coordinating individual links in the chain of values.

On the top level there are core competences which make the highest value for the business. They are a unique combination of resources and abilities in different areas of company's functioning. Core competences are created as a result of the synergy of the resources constituting the company's value and its unique resources, as well as the ability to coordinate and to make an effective use of these resources. A skilful manipulation with core competences (e.g. coordinating various manufacturing activities, integrating numerous technologies) results in new products and added value for the client.

The essence and characteristics of organisational competences

Despite numerous differences, there is a consensus that competences are one of the factors determining the company's success. Undoubtedly, competences make a conceptualisation of a new class of resources. However, it is necessary to distinguish competences, abilities and processes, though their hierarchical relationships are more important than accurate definitions.

M. Bratnicki (2000, p.13) distinguishes a concept of "*abilities*" which he assigns to human individuals, and that of "*competences*" which he refers to the level of the entire organisation. In his opinion competences mean integrating knowledge (the abilities of individuals and resources) in order to achieve a goal. Competences understood in this way are in fact the abilities of the people managing an organisation and having influence on making the most vital decisions. They are abilities to acquire adequate resources, including people, and to use them properly in order to carry out the adopted strategy.

Competences make a company distinct in its environment and give it the competitive advantage. Like in the case of other resources which are decisive for competitiveness, competences must be valuable from the perspective of the activities that are run, they must have the quality of rare goods and be difficult (or/and costly) to imitate.

Summing up the reflections referring to competences, the latter can be defined as a combination of knowledge and abilities which reflect both the resources of basic (hidden) knowledge and the abilities which are indispensable to perform necessary activities. Competences are based on the knowledge inherent in the skill sets of individual employees and the knowledge that remains at the disposal of particular organisational units.

In this context the major role is played by the knowledge and abilities accumulated by the company throughout a long period of its functioning. A quick imitation of this type of resources is difficult, bearing in mind the necessity to invest in time- and money-consuming process of learning.

In literature, competences are usually seen from a twofold perspective:

1) as assets, abilities or resources owned by the company and enabling its running systematic activities,

2) as the activities themselves, which can be performed by the company thorough its composing different sets of resources.

The latter approach emphasises what the company really does, rather than what it has at its disposal. Competences are manifested here as the effects of actual activities undertaken by the organisation. According to W.C. Bogner and H. Thomas (1994), both these perspectives lead to better understanding of the idea of organisation's competences. In their concept, organisational competences can be considered in the cognitive aspect depicting the knowledge and abilities owned by the organisation, and in the active aspect presenting the activities carried out by the firm. Hence, competences can be defined as the company's specific abilities to distribute its resources, as well as its cognitive abilities which enable taking up the activities necessary to achieve set goals.

Adopting similar assumptions, R. Sanchez (1996) defined three properties which should characterise organisational competences:

- they must have an organisational component, i.e. they should refer to coordinating and distributing resources;
- they must have an intentional component – they should result in well thought-out actions aimed at ensuring well-coordinated distribution of the resources;
- they must have a purposeful component – coordinating the resources should lead to reaching organisation's goals.

D. Turner and M. Crawford (1994) contrast organisational competences with individual ones. Individual competences include the experiences, knowledge, abilities and skills of individual people. Organisational competences make a combination of the abilities and knowledge belonging to the organisation as such. These competences are inherent in organisation's processes, systems and structure and adopted by all its members. Competences understood in this way are kept even when individual employees leave the organisation. Organisational competences are based primarily on sets of routine actions making the basic, organisational system of knowledge storage and setting regular routines. As claimed by R. Nelson and S.G. Winter, routine activities have the same role in the organisation as abilities and skills to individual people.

Considering the role of competences in acquiring and maintaining the competitive advantage, their four qualities should be noted: tacitness, robustness, embeddedness and the management's awareness of their existence (Wernerfelt, B., 1984):

- *Tacitne***ss** of competences reflects the range within which competences are difficult to codify or to communicate. As far as this criterion is concerned, competences can be arranged on a scale on which the beginning is marked by competences that are possible to articulate and the final point by hidden competences. Articulable competences may be given a form of instructions, procedures or principles which can be communicated orally or in writing, whereas hidden competences are based on intuitive knowledge and cannot be fully described or reported. Hidden competences are of particular value for maintaining competitiveness because they are directly dependent on the context of the company's functioning – consequently, they are difficult to imitate and make use of in a firm working in a different environment.

- *Robustness* of competences refers to their value and usefulness in rapidly changing conditions. Robust competences are hardly sensitive to changes in external conditions and will remain serviceable in a new situation. Non-robust competences, in contrast, are the ones that lose their usefulness when the environment is altered by changes which cannot be controlled by the organisation. Competences' robustness makes them more durable and resilient. Their presence increases the organisation's chances of gaining a permanent competitive advantage over its rivals.
- *Embeddedness* of competences reflects the ease or difficulty in transferring them to another organisation. This quality makes it possible to predict what will happen to the organisational competences when the employees using them leave the company. Such a property of competences results from their position in the organisation: if they are placed in some elements of a widely understood system of management or information they are easier to recreate after the employees have left. If they remain only in the memory and awareness of the employees they will be lost at the moment of the staff members quitting.
- *The level of awareness of organisational competences together with management's consensus* reveals how similarly the management of the top and middle levels perceive organisational competences and understand their role from the perspective of the firm's activities.

Even though the meaning of consensus in this area among top management has been extensively documented, the need to agree on the opinion in this respect with middle management is still underestimated. Middle-level managers are responsible for interpreting and communicating the visions and strategies formulated at the top level of management. If they manage to communicate also the agreed opinion concerning the most valuable resources decisive for the competitive advantage of the firm, its practical use will be facilitated and the organisation's efforts will be focused on priorities.

Summing up the analysis of competences, a few generalisations can be made:

- competences may be understood as a possibility or an ability to obtain a definite result, or a result on a definite level (the ability to perform definite tasks or reaching particular goals);
- their character is always relative and they must be referred to a certain standard, a goal or a task assumed. While analysing competences, it is necessary to start at some point of reference which is present in the question: "competences to do what? And/or in what area?";
- they are manifested through the ability to act adequately to the requirements of an individual situation.

COMPETENCY GAP

One of the main ideas to understand competency management is to define the gap.
To a contemporary manager, the role of competency gap is increasing and it becomes necessary to identify and reduce it. This results primarily from the fact that in contemporary global economy competences are a resource which decides about the business's success. The concept of *competency gap* may be understood as:

- „a lack or a deficiency of abilities" needed to: reach the organisation's goals and tasks; or to obtain results which are regarded by the management as "attainable" with the material and human resources of the company; or to obtain results attained by the leader or a group of the best companies in a given line of business.
- the difference between the desirable competences (according to the managers) and the existing ones, and between the structure and level of the competences owned by the management and the competences that are desirable or required.

It should be noted that contemporary managers have fewer problems identifying competency gap existing at a given moment. They have precise information regarding their competition on the market, and frequently are provided with the financial data in this respect. However, the major barrier is the recognition of the methods reducing such a gap and their effective implementation.

Competency gap is of a dynamic character and to reach the complex knowledge of this phenomenon it is necessary to adopt an analytical perspective taking into account not only the approach in the context of broadly understood organisational „resources" (or the potential of the organisation) but also in the context of their active use .

Competence management means identifying gaps and initiating actions aimed at their reducing. Functioning in a turbulent environment makes contemporary enterprises face a necessity to constantly adapt to new challenges, particularly to the intensifying processes of internationalisation and globalisation. Thus, it is necessary to adequately identify and analyse signals received from the environment, taking into account their influence on the current and future situation of the company, as well as anticipating, on the basis of such signals, the directions in which the environment is changing and some indispensable core competences which condition the functioning of the enterprise in the future.

RESERCH METHODOLOGY

The aim of the study is to determine the relationships occurring between competence gap management and improved effectiveness of an enterprise.

The following *hypothesis* has been formulated:
H 1. There are different methods of reducing competence gap in an enterprise, such as: acquiring natural resources, finding financial resources, introducing elements of knowledge management, finding specialists on the job market, acquiring competences from a business partner, collaboration with consulting companies, cooperation with scientific and research institutions, training courses (internal and external), building up company's own research and development potential, learning in action, learning from competitors and outsourcing. Among these, some methods are used particularly frequently in order to improve the company's performance.

We designed a research process consisting of two stages:

1) literature study,
2) empirical study – quantitative

Table 1.. Methodology of quantitative study.
Source: *Authors' own analyses*

Elements	Description
Type of analysis	Quantitative study
Research method	Selected methods used in statistical analysis
Research tools	Questionnaire, correlation analysis, factor analysis
Sampling method	Purposive sampling
Tools used to arrange and analyze the data	MS-Excel spreadsheet, CSS Statistica 6.0 package
Method of presenting study results	Charts, tables

Research results

The frequency of the effect exerted by the methods of reducing competence gap on individual effectiveness components was varied in the analyzed group of companies and it looked as follows:

1) Reducing the number of errors and flaws (33.33%),
2) Improved time of adaptation to clients' needs (32.13%),
3) Increased income from operating activities (29.31%),
4) Improved image of the company (29.15%),
5) Reduced time of process implementation (29.03%),
6) Increased client satisfaction (26.93%),
7) Increased creativity of the employees (26.16%),
8) Reduced costs of operating activities (23.52%),
9) Improved financial situation of the company (21.58%),
10) Reduced staff fluctuation (12.05%).

Similarly, the frequency of the effect exerted on the individual components of effectiveness by reducing competence gap was varied in the individual enterprises. Detailed information regarding this issue is presented in Table 2.

Table 2. Frequency of the effect exerted on the individual effectiveness components due to reducing competence gap.
Source: *Authors' own analyses*.

1.	Increased income from operating activities	29.31	21.93	27.87	52.08	30.83	16.67
2.	Reduced costs of operating activities	23.52	22.81	21.84	31.25	24.00	19.45
3.	Improved time of adaptation to clients' needs	32.13	32.46	26.44	51.04	32.33	29.17
4.	Increased client satisfaction	26.93	23.25	23.56	47.92	28.00	18.06
5.	Reduced time of process implementation	29.03	23.69	27.30	47.92	29.33	26.39
6.	Increased creativity of the employees	26.16	25.88	24.43	33.33	27.00	19.44
7.	Reduced staff fluctuation	12.05	11.40	11.50	15.63	12.67	6.95
8.	Improved financial situation of the enterprise	21.58	17.11	21.55	32.29	23.00	9.72
9.	Reduced number of errors and flaws	33.33	32.46	31.32	42.71	33.50	31.95
10.	Improved image of the company	29.15	26.75	25.86	46.88	29.17	29.17

While analyzing the frequency of applying the total of the methods used to reduce competence gap in order to improve particular effectiveness components in selected groups of companies, it was observed that:

- small enterprises most frequently used the methods of reducing competence gap in order to improve each particular effectiveness,
- medium-size companies least frequently used the methods of reducing competence gap in order to improve the following effectiveness components: increased income from operating activities, reduced costs of operating activities, improved time of adaptation to clients' needs, reduced number of errors and flaws and improved image of the enterprise,
- large organizations least frequently used the total of the methods for reducing competence gap in order to improve the following effectiveness components: increased client satisfaction, reduced time of process implementation, reduced staff fluctuation and improved financial situation of the company,
- non-market companies, compared to market-oriented enterprises, much less frequently used the total of the methods designed to reduce competence gap in order to improve the whole of effectiveness components, except for improving company's image, where the frequency of implementation was identical like in market-oriented firms.

Quantitative studies resulted in diagnosing the frequency of applying individual methods of reducing competence gap in order to improve the total of effectiveness components. Detailed information regarding this issue is presented in Table 3.

Table 3. Frequency of applying particular methods of reducing competence gap in order to improve the effectiveness in the studied companies.
Source: *Authors' own analyses*.

1.	Acquiring additional material resources	32.85	29.47	32.07	43.75	33.80	25.00
2.	Acquiring financial resources	31.42	24.74	29.66	53.75	32.00	26.67
3.	Introducing elements of knowledge management	33.40	36.32	25.86	53.75	33.80	30.00
4.	Acquiring specialists on the job market	29.64	25.79	26.55	50.00	30.00	26.67
5.	Acquiring competences from a business partner	18.75	16.84	16.55	31.25	20.40	5.00
6.	Cooperation with consulting companies	20.00	20.53	16.21	32.50	19.80	21.67
7.	Cooperation with scientific and research institutions	11.61	13.68	9.31	15.00	11.40	13.33
8.	Training courses	42.69	40.53	38.96	60.00	42.60	41.67
9.	Building up company's own research and development potential	17.48	11.58	20.34	21.25	19.00	5.00
10.	Learning in action	39.99	34.21	42.42	45.00	42.00	23.34
11.	Outsourcing	13.57	12.11	10.35	28.75	13.80	11.67
12.	Learning from competing companies	24,43	19,47	21,72	46,25	25,20	18,33

The results of the studies prove that the frequency of using the particular methods of reducing competence gap in order to improve the total of effectiveness components was varied. The most common method used to achieve this aim was organizing training courses. On the average 42.69% of the companies used this particular method to improve their effectiveness components. A popular method was also learning in action (39.99%). The least popular strategy of reducing competence gap in order to improve effectiveness in the studied enterprises was cooperation with scientific and research institutions, which was used by merely 11.61% of the analyzed companies. Outsourcing was not much more popular, as only 13.57% of the studied units were interested in applying it. Attempts to have positive effects in effectiveness, resulting from building up the company's own research and development potential (17.48%) or acquiring competences from a business partner (18.75%) were relatively rare.

It should be noted that small enterprises used all the methods leading to reducing competence gap in order to improve company's effectiveness more frequently than other groups of the organizations distinguished according to their size. Medium-size companies least frequently among groups of enterprises distinguished according to the criterion of their size used the elements of knowledge management, cooperation with consulting companies, cooperation with scientific and research organizations, training and outsourcing in order to improve their effectiveness. On the other hand, large companies were most

reluctant to improve their effectiveness by acquiring financial resources and specialists on the job market.

A large majority of methods used to reduce competence gap was applied more frequently in market-oriented enterprises, compared to non-market companies. The opposite tendency was observed only in case of cooperation with consulting companies and scientific and research institutions.

CONCLUSIONS

It turns out, however, that in the practice of Polish enterprises, despite the fact that the knowledge acquired in this way is indispensable to prepare a suitable strategy and to build consistently a set of adequate competences, in case of many businesses such knowledge does not make a basis for designing the directions for their future activities. The results of empirical examinations carried out by various teams suggest that the development of numerous businesses is a matter of chance, an unexpected opportunity, such as e.g. a possibility to purchase some extremely cheap fixed assets, a sudden offer to cooperate with a big company, using different relief funds offered by the European Union, finding a new investor, a company merger, favourable systemic solutions etc. (Sitko – Lutek, Skrzypek 2009) An opportunity of this type provides an impulse to act, though it depends on the company's competences whether and to what extent it will be able to take advantage of it.

Each of the enterprises studied came across such opportunities which affected, to some extent, its further functioning, and the success was determined by the company's ability to find and to use properly such an opportunity. Each of the enterprises identified in its own way the emerging competency gaps and initiated some activities in order to reduce them, which resulted in a consistent creation of the competences that helped the company's development.

The models of competence acquisition were different in the analysed companies, yet it can be concluded that he methods of identifying competency gaps they used were dependent, to a high degree, on the company's situation and the method of strategy building it adopted as a result:

- new opportunities implied an entrepreneurial approach characterised mainly by intuitive strategic choices; the aspirations of the owners/management were confronted with the opportunities and resources identified, with reference to the standards of the client, the competences owned were compared to the ones that were required to initiate and run a specific type of activity,
- using the adaptation approach consisting primarily of a flexible adaptation to emerging opportunities and threats, the enterprises were running systematic examinations of the market, analyses of the competition, analyses of customers' complaints, the reasons for clients leaving, marketing and financial indices; the clients requirements were considered and critical situations in the companies were analysed,
- using the developed procedures aiming at working out and consistent implementation of the adopted strategy, which is characteristic of the planned approach to formulate a strategy, Early Warning Systems were designed; benchmarking of domestic competitors and of the leader in a given branch were taken advantage of; moreover, similarly like in case

of the adaptation approach, market research was performed, as well as analyses of the competition and of customers' complaints, the reasons for clients leaving and the analyses of marketing and financial indices,

In the practice of the studied enterprises mixed forms of strategy building in an organisation were used, so the competency gaps found were identified in different ways.

Depending on the type of the competency identified, and also on a particular situation of the company, varied learning actions were undertaken:

- acquiring material resources – purchasing technologies, machines, construction investments etc.
- transfer of people – individuals or teams, having competences desirable in particular areas,
- acquiring knowledge through training courses, consultancy, cooperation with research institutes, as well as knowledge transfer within the company,
- adjusting to clients' requirements – mainly through meeting the needs of big clients, and also skilful defining the needs of individual clients,
- building their own skills,
- outsourcing.

In the context of organisational competence gap mangement, special role is played by *management's perception* which expresses, through the quality of the decisions taken, the way it views reality and, at the same time, plays a vital role in creating the portfolio of organisational competences (Sitko- Lutek, 2007).

The management's perception which is narrowed down or based on schemes suggests a decreased level of its competences (perception gap) and makes it impossible to see some relevant competency management activities. It can be thus stated that eliminating, or at least reducing, the perception gap occurring in a particular enterprise is the first and necessary step on the way to recognize other competency gaps that are taking place in it.

On many occasions competency management in a company is mutually related and, in specific conditions, lead to inertia routines.

The practice of companies' functioning proves that their managers come across serious difficulties in estimating quality categories among which there are organisational competences.

In case when competences are gradually completed when successive challenges emerge and they are properly handled, special meaning should be given to the process of "learning in action" which results in both an increase in the abilities of formulating an effective strategy of action and in its efficient implementation.

In the context of the strategy, competency gap can be analysed from the perspective of market environment in the form of emerging threats and opportunities. The reaction to threats may be different, depending on their strength and the chances to eliminate or to reduce the competency gap. On the other hand, opportunities in the environment offer

chances to become successful and the company tries to take advantage of those which remain in compliance with its competences or when missing competences can be relatively easily made up for.

Consequently, identifying competency gaps in companies is done intuitively and without taking advantage of the full range of methods and instruments. This poses a serious threat to the accuracy of diagnosing the competitive potential of the company. Therefore, one of the core competences in a company functioning in a turbulent global environment is developing effective practices in the area of analysing and assessing organisational competences and competency gaps.

Creating the awareness of existence, as well as identifying and eliminating competency gaps in the organisation can be implemented in the most effective way by means of corporate learning processes treated by the enterprises as their major philosophy and management practice.

A description of the methods and procedures of competency gap management may significantly contribute to developing an adequate methodology in the area of recognizing the need of corporate learning which occurs at the initial stage of the corporate learning cycle.
To sum up, organizational competency, competency gap and reducing the latter with the help of relevant methods may provide an interesting research problem. It should be also noted that organization's competencies make an important determinant of the company's success. For this particular reason, scientific research devoted to these issues may be of vital importance for economic practice

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INTERNAL AND EXTERNAL ANTECEDENTS TOWARD ORGANIZATIONAL LEARNING AND INNOVATION: A CONCEPTUAL FRAMEWORK

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ABSTRACT

In this day and age, it is easy to see that small and medium enterprises (SMEs) play an essential role in the growth of the Thai economy. The rapid change in the world economy and its social repercussions has also influenced the aforementioned SMEs. In the case of Thailand, SMEs have faced many problems that affect business performance. An essential issue for Thai SMEs is the growing competition not only from inside the region but also from abroad. Consequently, SMEs must adapt and improve themselves in order to survive. A key challenge of modern organization is to develop a knowledge-based organization. As Drucker (1999) has proposed, the present competition is to shift from focusing on manual worker productivity or labor-intensive to a more knowledge-intensive-based form of work. The theories of organizational learning and innovation are widely used in modern organizations in order to accomplish their goals and build up their organizations. The purpose of this study is to develop a framework for organizational learning and innovation in the case of Thai SMEs from various standpoints including internal factors and external turbulences. The qualitative method was employed in a semi-structured interview technique used as the data collecting tool with the literature review also performed along the way. The results from the interviews were identified by conjunction with the literature. Seven interviewees from electronics, and automotive component companies were selected. As a result, the internal antecedents included leadership, culture, motivation, and information technology. The external antecedents were market turbulence and technological turbulence.

Keywords: Organizational learning, innovation, SME, Thailand

INTRODUCTION

Nowadays, one could say that small and medium enterprises have become an essential part in the growth of the Thai economy. According to the report of the Office of Small and Medium Enterprises Promotion 2010, the amount earned by Small and Medium Enterprises (SMEs) in Thailand was around 2.9 million or 99.8 percent of all private enterprises in the country. Moreover, they also helped generate the Thai GDP by as much as 37.8 percent of the national income. The hiring rate among SMEs was around 9.7 million workers or 78.2 percent of all enterprises. Therefore, it is fair to say that SMEs constitute the most important mechanism driving forward the Thai economy. Consequently, increasing the potentiality of SMEs is an important issue in Thailand. Both public and private sectors in Thailand recognize the importance of SMEs in improving the economy of Thailand, then

many organizations had been established with help from both sectors for the purpose of supporting and enhancing the performance of SMEs, such as the Office of Small and Medium Enterprises Promotion (OSMEP), Institute of Small and Medium Enterprises Development (ISMED), SME bank of Thailand, the Thailand Research Fund (TRF), and many commercial banks.

At the present time, the rapid change in the world economy has also influenced the SMEs. In the case of Thai SMEs, one challenge for them is the growing competition from both inside and outside the region. Moreover, free trade agreement with other countries such as USA, Australia and China will also affect the Thai economy and SMEs as well. SMEs must then adapt and improve themselves in order to survive. In recent years, SMEs faced many problems that affect business performance such as the uncertainty of the Thai political situation, natural disaster, high competition, high cost of labor, and lack in required knowledge. The ISMED 2008 categorized the current problems of Thai SMEs into eight issues, namely: marketing problem, labor problem, lack of capital, technology limitations, lack of modern management knowledge, insufficient support from public and private sectors, restrictions on access to the service of the public sector management, and restrictions on access to information.

To improve the SMEs' performance, one challenge of modern organization is to develop their knowledge-based organization. As Drucker (1999) mentioned, the present competition is to shift from focusing on manual worker productivity or labor-intensive to a more knowledge-intensive nature of work. To retain the useful knowledge within organization as long as possible, the theory of organizational learning, which is widely used in modern organization, was a focus of this study. Moreover, to survive in competition, innovative ability is also required in every organization. Hence, this study is focused on organizational innovation as well.

In addition, this study aims to develop a conceptual framework for internal and external antecedents towards organizational learning and innovation of SMEs in Thailand. Such a conceptual framework could provide a better understanding of the role of relevant factors and their influence. Furthermore, the qualitative method was also employed in this study. The semi-structured interview technique was used as the collecting tool. This paper is organized into four sections. The first section describes the nature and context of SMEs in Thailand from the literature review. The second section emphasizes on the methodology and sample of this study. The third section identified the internal and external antecedents of organizational learning and innovation, and its consequence. Moreover, the conceptual framework is constructed in this section. The final section is identified the limitation and further research of this study.

SME IN THAI CONTEXT

Each country defines SME differently. In the case of Thailand, the Institute of Small and Medium Enterprise Development described SME as follows: *"SME stands for small and medium enterprise that operates the business in production, trading, and service business sector."* According to the Small and Medium Enterprises Promotion Act of 2000, the type

and characteristics of SMEs can be categorized by the enterprise's fixed asset and number of employees as shown in Table 1.

Table 1: The type and characteristics of SMEs.

Type		Number of employees		Fixed asset (million Baht)	
		Small	Medium	Small	Medium
Production sector		< 50	51-200	< 50	51-200
Service sector		< 25	51-200	< 50	51-200
Trading sector	Wholesale	< 25	26-50	< 50	51-100
	Retail	< 15	16-30	< 30	31-60

First, the production sector includes the agricultural processing, manufacturing, and mining industries. Second, the trading sector includes the wholesale and retail businesses. Third, the service sector includes the service business such as hotel, restaurant, and spa businesses.

Some benefits of SMEs to the Thai economy (Ministry of Industrial, Thailand, 1999) are described as follows:

- To create jobs in every regions of Thailand: the SMEs were established in almost every region of Thailand in order to create jobs for the people in their regions. In other words, it is the distribution of income to the people in the rural area as well.
- To generate the high value-added of products: the SMEs can bring in benefits from exporting their products and also creating foreign exchange earnings. Moreover, they can also produce goods as import substitution which can prevent a lot of foreign goods being imported.
- To support and link large, medium, and small enterprises with each other in the form of primary production of raw materials or goods by manufacturing employment of subcontracting.
- To be a source of experience available to entrepreneurs, especially those who are in the start-up point of new businesses and investors can expand their business from small to ultimate growth.
- To link between the industry and other relevance such as trading, logistics, agricultural, and construction sectors.

METHODOLOGY

Theoretical framework typically originates from the data that could create new ideas or improve existing theories (Holloway, 1997). In this study, the qualitative method was employed in order to create the theoretical framework. Qualitative research usually focuses on human perception, behavior, and experiences with the purpose of improving theories or experiments (Stake, 2010). It has been applied and used in many research works in both the social and science fields. A semi-structured interview technique was used as the data collection tool. Moreover, a literature review was performed along with the whole data

collection and analysis processes, with the purpose of clarifying and comparing the evolving results.

For the sample of this study, five Thai SMEs companies were chosen based on our criteria. First, the selected companies are in the production sector and are located in the Bangkok metropolitan and perimeter areas, where there is high concentration of SMEs, and the premium business-infrastructures are provided in this area rather than the rural areas. Second, the medium size companies selected for the analysis each has the number of workers between 51 and 200 as well as the size categorization of ISMED. Then, there were in total seven interviewees who participated: three were two engineers and one technician from automotive and components companies; and four were two engineers, one technician, and one manager, who were willing to be interviewed for this study. Each interview was approximately 20-30 minutes. The questions were open-ended in semi-structured interviews. After a comprehensive literature review and semi-structured interview with Thai SMEs, a conceptual framework of organizational learning and innovation was developed as shown in Figure 1.

CONCEPTUAL FRAMEWORK

Organizational learning in SME

Even though the SME is a small or medium size business, the continuous performance improvement must be considered in order to keep pace with the rapidly changing economic conditions and global competition. Nowadays, the shifting from a labor-based economy to a knowledge-based economy, such that knowledge, which is an intangible asset, becomes an important weapon of organizations for competition. As such, management and sustaining of knowledge is a critical issue for organizations. One challenge for management of organizational knowledge is the organizational learning theory. It can be described as “a process that gathers information from both the external and the internal environments of organizations. This information is assimilated by organization members through collective struggle behavior which produces shared visions that can be used to make changes to lead to an organization’s success” (Chen, 2006). Many researchers focused on the research work of organizational learning in large companies rather than in SME companies including the research work of SMEs in Thailand.

Organizational Innovation

Nowadays, it is undeniable that innovation is an important driver in the improvement of performance, whether small or large organizations including SME. This requires an innovation process to improve and develop their organizations such as the development of product or process innovation. In the case of SME, their characteristics differ from large companies, for example, producing a variety of products in order to fulfill customers’ order, modern products or services. Moreover, not only can the needs of customers be changed all the time along with new technology, but also the external turbulence and competition lead SME to improve themselves such as the tools, machines, management system, and skilled and trained workers. In other words, innovation improvement is a critical issue of SME.

Antecedents of organization learning and innovation

After a comprehensive literature review and semi-structured interview, the four internal antecedents and two external antecedents were selected and described in this section. Internal factors consist of the following four: leadership, information technology, culture, and motivation as shown in Figure 1.

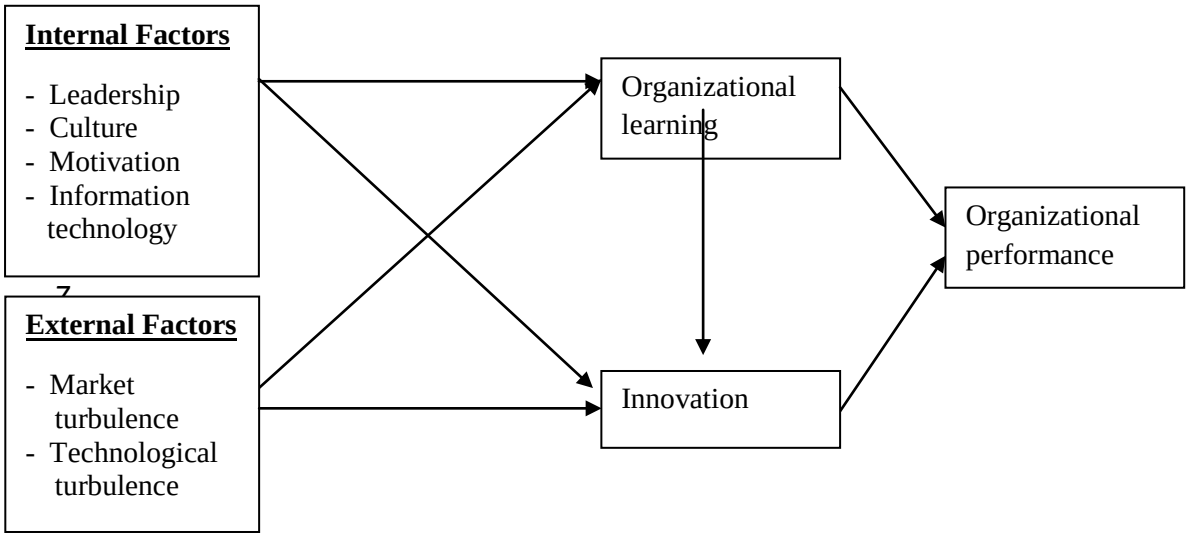

Figure 1: The conceptual model.

Leadership

Many decades ago, much has been researched on the theory of leadership with the purpose of developing the organization. The leader is also called manager in much of the literature. The roles of the leader include planning, hiring, motivating, and rewarding employees. However, the role of leadership does not only involve managing the organization but also encouraging, facilitating, and sustaining the innovation and learning (Yukl, 2009). Moreover, the needs of employees should be considered in order to have them integrated with the organizational system. The style of leadership, especially transformational leadership, could directly and positively influence organizational learning and innovation, all of which could be improved by processes such as training and mentoring (Jung et al., 2003; Vera and Crossan, 2004).

In this research, the researcher observed that the nature of Thai SME is such that the manager is the owner and thus contributes the tasks on a daily basis to all departments such as planning, controlling, R&D, hiring, motivating, organizing. Moreover, these SME managers have to face and solve problems on a day-to-day basis by themselves. One interviewee argued that:

> *"Our manager plays an important role in our company and he has to make the decision in almost all activities in the company such as hiring the staffs, providing our training course, and investing in new technology. … He is the central link and drives the relationship among staffs in our company."*

Additionally, Senge (1990) described that this new perspective of leadership could lead the organization to become a learning organization. On other words, poor leadership will instill a low capability for a learning culture in the organization. Furthermore, organizational learning can be enhanced by motivation such as pay incentive for creating new ideas for innovation, or building a climate and culture that lead to learning (Achua and Lussier, 2010). The engagement between staffs and manager will lead to SME development and continuous growth.

Culture

As Drucker (1975) mentioned, the management system is concerned with people, culture, and performance. One challenge of organizational development is organizational culture. Culture is traditionally referred to as intangible, a set of values, beliefs, and symbols that make the community an organization. Additionally, each organization has its own culture. Schein (1992), who is an expert in this field, defined organizational culture as "a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way you perceive, think, and feel in relation to those problems" (p. 12). Moreover, Dwivedi (1995) mentioned that organizational culture also has influence on the attitude and behavior of employees that will lead to organizational improvement. In comparison, the strong organizational culture will lead to improving innovation, supporting teamwork, and increasing efficiency, quality, and productivity, while a weak organization culture could block the creating of new ideas, processes, and systems (Morgan, 1989).

In this study, the management system of Thai SMEs was the clan culture which was flexible and focused on the staff. One interviewee from an automotive component company mentioned that:

> *"Our company manages just as the relationship system. It has the munificence, and gives the opportunity for everyone to share ideas and make comment that is of benefit to our company."*

Increasing the robustness of organizational culture will lead to a learning organization (Chang and Lee, 2007). Moreover, the organization culture could be changed to organizational commitment by managing the relationship between leader and employee (Singh, 2007). Then, strong leadership will lead towards changing the organizational culture for the better.

Motivation

Motivation is an important role of the organization's manager: "Motivation is the set of forces that leads people to behave in particular ways" (p. 83). The theories of motivation were established by many theorist and researchers, for example, Maslow's hierarchy of needs theory included the physiological, security, belonging, esteem, and self-actualization

needs. Moreover, Herzberg's dual-structure theory consists of two essential factors, motivation factors such as achievement, recognition, and hygiene factors (e.g. pay and job security), and working conditions. Nowadays, there has been a tangible shift from the scientific management area which focused on the worker motivation by money to the human resource area with the focus on worker motivation and the contributions to the organization (Griffin, 2010).

In this study, the interviewees of Thai SMEs agreed that motivation was an important factor in driving the worker to pursue organizational learning and innovation. Some interviewees believed that if a comparison is made between the motivation source of large organizations and SMEs, most large organization provide better motivation than SMEs such as the pay incentives, rewards, and promotions at work. However, the primary remuneration and welfare such as social security are also provided in all SMEs.

> *"Our company has programs that give rewards to the idea that makes the most benefit such as part design improvement. …The training programs are provided for some staffs, not for all staffs in our company. However, I think they should provide training for all staffs as someone who is willing to learn is better than training according to the plan."*

Moreover, one of the interviewees recommended that the work environment and relationship between workers, colleagues and leader in the workplace were also important factors which could lead to motivate the worker's commitment to the organization. Moreover, sometime the innovation of SME could result from worker motivation such as giving rewards to new ideas.

Information Technology

Nowadays, information technology plays an important role in daily life and business. It has a lot of benefits to the organization such as enhancing the competitiveness and organizational performance (Potter and Millar, 1985; Croteau and Bergeron, 2001). The role of information technology in an organization includes controlling and storing data, learning and development. Moreover, the use of information technology to increase communication among members in an organization, as well as memorizing and storing information could also enhance organizational learning (Robey et al., 2000). Moreover, the high information technology capability of the organization will lead to a variety of profit- and cost-based performance measures (Bharadwaj, 2000).

In this study, from the interviews, all agreed that information technology is very important for their business because it can create many benefits and value added to their business such as transferring market data, communication with vendors and customers. Hence, they endeavor to apply and use information technology to develop their performance such as learning new knowledge from external sources, using electronic commerce or social networks to communicate with their customers and vendors.

> *"IT is needed for all part of our business. Communications via IT are very important activities both in terms of communication with customers and*

external persons but also between staffs. …However, the investment in IT is a decision to be made by our manager."

Moreover, the SME preferred to use the service from the computer agency in performing their business rather than employing a computer technician because the wage for the agency is lower than hiring a full-time computer worker. The amount of IT investment is based on the type of business and the decision making of the leadership while firm size is not an issue (Love and Irani, 2004).

External Factors

After the global economic crisis, every country faced its devastating impacts regardless of whether developed and developing countries. Thailand is one country that was directly affected in many sectors such as export, manufacturing, and service sector. These directly impacted the people, public, and their business, especially whether it could reduce the number of employment, production, and delay or reduce investment in Thailand, etc. One important factor characteristic of this situation is turbulence. Turbulence is defined as the change, uncertainty, instability in the external environment (Smith, 2005) and has both direct and indirect effects on organizational performance. Two types of turbulences were considered in this study, namely, market turbulence and technological turbulence.

Market Turbulence

Market turbulence (also called market dynamism or demand uncertainty) is defined as "the rate of change in the composition of customers and their preferences" (Hanvanich et al., 2006). Market turbulence can be categorized into five types such as customer, channel, competitor, macro-environment, and value proposition turbulence (Smith, 2005).

In this study, after the in-depth interview, the interviewees agreed that market turbulence was one factor that was difficult to control. One interviewee from the electronics company mentioned that:

"Our model has changed quickly due to customer needs…. Learning from external sources or benchmark with others….creating an innovation in our organization in order to increase the value-added to our products and make us different from the competitor. This will bring satisfaction to our customers and gives us the competitive advantage."

Organizational learning could be increased by forcing market turbulence (Hanvanich et al., 2006). And since customer preferences are unstable and change quickly, the innovation must be quickly changed in order to satisfy them.

Technology turbulence

Technological turbulence is defined as "the amount and unpredictability of change in production, process, or service technologies" (Srivastava and Frankwick, 2011). This is the factor that could determine the life cycle of existing products. For example, the products

with fast technological advances or high technological turbulence will have a short life cycle, while the low technological turbulence of products will perform in the opposite direction. Moreover, sometimes the product life cycle can grow and the new technology could occur in those cycles.

In this study, after the in-depth interviews, most of interviewees agreed that technological turbulence has an influence on their performance, especially among electronic companies, who seem to have been greatly impacted at least according to one interviewee from an electronic company:

> *"Technological turbulence comes around us all the time due to electronic products which have changed over time. Everything in our company also changed accordingly such as the machine, process, and knowledge about new technology. Then, we have to prepare ourselves in order to deal with it such as preparation of learning and training our staffs on the new technology. This way is quite better than hiring a new expert that requires a high investment. Moreover, this is the way to improve our staff ability as well."*

Even though many companies or businesses agree with the above, however, only one interviewee from the automotive part company seems not to agree:

> *"We did not get any effect from technological turbulence because we produced unique products of which we're the sole producer in Thailand. Moreover, our products do not need a lot of change because it is the foundational part of automobile."*

The requirement of technological development is an essential competitive strategy. Porter, (1985, p. 171) defined technological development as "raise or lower scale economies, make interrelationships possible where they were not before, create the opportunity for advantages in timing, and influence nearly any of the other drivers of cost or uniqueness". In other words, the products with low cost or are differentiated will lead the organization to be more competitive and could also create organizational innovation. Moreover, technological leadership will be required in order manage the costs of such learning activities and innovative technology (Porter, 1985).

Consequence of organizational learning and innovation

In this study, organizational performance was identified as the consequence of organizational learning and innovation. In order to know the current competency level of an organization, the measurement of the overall organizational performance should be recognized (Kaplan and Norton, 1996). The measurement of organizational performance is typically categorized into two types which are non-financial and financial measurement. A Tool for measuring non-financial performance is for example the balance scorecard, while the tools for measuring financial performance are the APC model and the MFPMM technique which were developed by the American Productivity and Quality Center. (Rao, 2006; Phusavat and Photaranon, 2006). The key performance indicators which are widely used in performance measurement include quality, cost, delivery, flexibility, creativity,

marketing, production, finance, innovation, and public relation (Kaplan and Norton, 1996; Cooper and Kleinschmidt, 1987; and Zhang et al., 2004).

CONCLUSION

The conceptual framework is illustrated in this study, is still in the first step and requires the further empirical investigation. As this study, the qualitative method was employed for construct the conceptual model, then further research, the quantitative method would be employed with the purpose of investigating the answer and reflecting the data. Moreover, the framework identified in this paper can be used as a guideline for organizational development to enhancing their learning and innovation ability. To sum, the conceptual framework identified the internal antecedents of organizational learning and innovation which included leadership, motivation, culture, and information technology. All of them were the internal factor of organization that could be focused on because they had been influenced on organizational learning and innovation. Moreover, the external antecedents included two factors which were market turbulence and technological turbulence. Both of them were the important factor of SME because they were the uncertainty factors and had the high risk.

LIMITATIONS AND FURTHER RESEARCH

The limitations of this study have to do with the sample which was selected from the SMEs in Thailand and all of them were in the industrial sector. First, the comparison across different sectors could be demonstrated. Then, these could provide a better understanding of the different industries with their different competencies. Second, the comparison across different countries could be considered. These could provide a better understanding of the different factors that influence organizational learning and innovation, such as the comparison between SMEs in Asian and European countries. Third, the comparison across cultures could be included. This could provide a better understanding of the different socio-cultural factors that influence organizational learning and innovation, such as the comparison between Japanese-Thai SMEs entrepreneurs and original-Thai SMEs entrepreneurs. However, the purpose of this study, which is to create a conceptual framework, will not be answered unless the hypothesis is constructed and tested in further research (Patton, 1989).

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LEADERSHIP BY TRUST FOR ORGANIZATIONAL INNOVATIVENESS: RENEWAL OF HUMAN INTELLECTUAL CAPITAL IN FOCUS

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ABSTRACT

Trust is the essence of leadership. Leaders enable the creation of trustful workplace climate that gives support to innovativeness. The paper discusses and examines a highly timely topic of trust in organizations from the leadership perspective. The focus is on the role of trust in renewing human intellectual capital which is a crucial resource for sustaining innovations (Savolainen, 2011). Originality of the paper is based on the two ideas; First, defining leadership by trust as leader resource, skill, and intangible asset. Second, examining trust in leadership as enabler of the renewing of human intellectual capital. The paper provides a novel view into managerial leadership, since trust, leadership and the renewing of intellectual capital has hardly been examined integrated. The main point of discussion is crystallized in the suggestion that leading with trust enables the renewal and growth of human intellectual capital which is of utmost importance for sustaining innovativeness and competitiveness in business organizations. In the practices of renewing intellectual capital, sharing of knowledge is one of the key activities and processes. Trust is needed more in this context. The discussion paper advocates the idea that, in managerial leadership, it is important to understand antecedents, formation, and consequences of building and sustaining trust. The paper presents also real life examples from two case studies. They illustrate the practices of building and sustaining trust through leadership.

Keywords: intellectual capital, intra-organizational trust, innovativeness, intangible assets, leadership by trust, tacit knowledge, sharing, case study, qualitative

INTRODUCTION AND PURPOSE

Trust in organizations is an antecedent and a way to build innovative work environments in the knowledge era. In organizational renewal, co-creation, interaction, and relationships are stressed more and more. Trust is thus needed more but enacted less. Trust is a relational concept meaning that it develops in interaction and reciprocal activity between organizational actors. The main part of leadership work is about relationships, interaction, communication, sharing, and collaboration. As the service-dominant logic has permeated in global markets and exchanges (Lusch et al., 2007), services and processes undergo renewal.

For this organizational innovations and not only technology innovations are needed in private and public sector organizations. Leadership and HRM are the focal intellectual resources in the renewal activity.

Trust is hardly examined as intangible, forceful resource and asset in leadership. Although building trust is listed as one of the main elements and tasks of leaders (Yukl, 2010), the knowledge gap exists how leaders enact on trustful leadership and show trustworthiness in daily actions. Trust in workplace relationships is still scarcely studied, despite of the fact that leader-follower relationship is one of the key actor relationships in organizations. Recently the importance of trust in leadership has been widely recognized in the literature and practice. In Finland the Finnish Innovation Fund (SITRA) has raised 'new leadership by trust' as a paradigm for the future in the development program report "Elinvoimainen Suomi", Vibrant Finland (Nurmio & Turkki, 2010). Building trust in leadership has been prioritized nationally as the top theme in leadership education for sustaining our vitality and competitiveness.

The paper discusses of building trust which is also based also on real life examples. The purpose of the paper is to stimulate discussion and shed light into the importance of and issues related to trust in leadership for organizational innovativeness. Further, the objective of the paper is to increase awareness of the role, nature and consequences of trust and influence of trustworthy or untrustworthy leadership behaviour on people in workplaces. The topical question is: Do we want to nurture or hinder freedom, appreciation, openness, sharing, creativity and ideas? All of these elements are needed for innovativeness in current workplaces. The paper presents theoretical views of how trust, leadership and innovation are related, and, some examples and implications are presented of trust in intra-organizational relationships to support innovativeness.

As organizations become more knowledge intensive, event- and opportunity-oriented, the strategic challenge for gaining critical competitive advantages increases. Human activity builds on knowledge and knowing and their varied invocation. From this perspective, trust is a significant human intellectual resource, because it is formed through and between people.

THEORETICAL DISCUSSION

Concept of trust

Trust is looked as a relational concept in the paper (Mayer et al., 1995) and within intra-organizational, and leader-follower relationships. Trust has been defined in many ways. Yet, the concept remains without a generally accepted definition (McEvily et al., 2003). In this paper, *the relational definition of trust* is adopted from Mayer et al. (1995, 712) as follows: "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party". Mayer's model of trust integrates the factors of trust formation in organizations between actors, i.e., in a relational context. Theorists have suggested that trust evolves over time based on a series of interactions. Trust is a person's assessment of another's *trustworthiness.* Trust describes the

positive expectations of a person in relation to the object of trust behaving respectfully also in situations of risk. Risk taking is at the core of trust, not taking risk per se, but rather a willingness to take risk (Mayer et al., 1995). Cooperation and confidence are used as concepts closely related to trust (see Schoorman, Mayer and Davis, 2007).

Trust is combined of several components - rational (cognitive) and affective. The elements that underlie trust-based relationships are the individual's feeling of being competent, a feeling of safety and caring, a sense of autonomy and empowerment, consistency and fairness in social relationships, congruence in the values of an individual and the organization (Savolainen, 2009, 2000). Trusting relationships imply trustworthiness. Credibility, fairness, competence with good intentions, and benevolence belong to the widely recognized dimensions of trustworthiness (Möllering et al., 2004).

Trust as intellectual, intangible asset

In organizational renewal, trust is an internal motivational force for individuals to develop their intellectual capital. Trust is seen as a foundation for cooperation, and an ingredient for creativity and freedom. Trust is manifested in collaborative culture characterized by open communication. Human intellectual capital includes areas such as competences, motivations, communication, sharing of knowledge, and cooperation skills. Trust may become more powerful intangible asset in the development of collaborative workplace cultures. In e-, virtualizing and multicultural world, cooperation and co-creation will be the keys for innovations, and for sustaining competitiveness. It is the environments of 'coopetition' that seem to emerge and conquer the most inspiring workplaces to be. And they will be the ones that reflect trustful climate.

Trust is intangible resource for both individual and organization. In the workplace context, resources such as trust are used and "owned" by the organization, in principle. Trust is multi-level and reciprocal in nature. This means that the effects, means, and consequences of trust concern both the individual and organizational level. Interpersonal communication and norms create for people a sense of security and an opportunity to identify with a group (Mäkipeska & Niemelä, 2005). Rewards in work relationships are accumulated by individual players' stable relationships and bonds through consistent interaction, which makes it possible to maintain them. Over time and through mutuality the predictability of the other player's actions increases. Subsequently, in co-operation one party can trust the other that he or she will not act deceptively trying to gain short term advantage.

Intangible assets are managed by the organizations and are accumulated from the human capital. Human capital is connected to an individual and disappears with him or her in contrast for example to technological capital and information, which is accessible to all. Even though human capital is strongly grounded on the individual, it is also organizational. The individual builds and breaks trust, but the benefits and unfavorable effects spread to groups and organizations. When individuals build, maintain, or damage trust, they obtain benefits or losses. More broadly, the effects are seen in different structures and processes in the organizational and societal level. This especially applies ethical activities. An individual's unethical actions propagate detrimental consequences to the organizational level and even the entire society. The most blatant examples of this are the pyramid

schemes, in which one individual's betrayal of trust leads to very serious and vast negative consequences.

In short, intrinsically trust can be built or destroyed by an individual, but he or she alone cannot utilize it or carry its unfavorable consequences. They influence relationships and structures, socially and collectively. Individual trust can be invisible and even "tacit", easily breakable and fragile. On an organizational level it is usually more tangible and can be sensed for example in the culture and atmosphere as well as in various relationships of influence, say between a leader and a subordinate. In conclusion, the purpose of trust is essentially to facilitate and ease co-operation. Trust is invisible and intangible but its benefits and consequences are multifaceted within organizations and between actors.

Trust in organizations and leadership

Pertaining to intellectual capital leadership by trust plays two roles in organizations. First, trust is an influential force and human intellectual capital for leaders in enabling and building trustful climate. Second, leading with trust is a means and skill to develop human capabilities for the competitiveness of the organization. Considering that work today is largely expertise-based by nature and is strongly based on creating and sharing knowledge, development of human capabilities and the work environments for utilizing them become prioritized.

Trust is a psychological and functional state. An individual is going to take the risk of being vulnerable with the anticipation that he or she will have a positive expectation of the intentions and actions of another (Dirks & Ferrin, 2002; Rousseau et al., 1998). The person takes action based on his or her beliefs (McAllister, 1995) and may have to face disappointment when expectations are not met. Thus trust in work relationships is dynamic and varying. It grows from the basis of relationships depending on the character and functionality of those relationships. This is described for example in Laaksonen's (2010) research on trust formation in a team. It was observed that trust resembles wave like motion with its "surges, spatters, and calms". Trust can be seen as an opportunity to get an access to knowledge, political, economical, and relational resources which are controlled by individuals (Keskinen & Teräs, 2008). It is also an opportunity to create loyal relationships which do not deteriorate or break easily. In the long run, these relationships are human resources which become rooted in and stratify as social and cultural intangible capital.

Trust creates vitality for the organization

Organizations are in need for vitality in order to sustain innovativeness and competitiveness. Vitality is about energy, will, spirit, activity, influence, collaboration, courage and ability to see opportunities and make changes. Vitality is enabled by different resources such as social and cultural foundation and heritage. Trust as intangible resource belongs to them. Vitality is created by individuals and in collaboration between individuals. Leaders enable and create (or ruins) vitality in organizations. Trustworthiness is one of the essential leader traits

and skills gained and trained in interaction with people. The very concept of interaction is a common denominator for a number of leadership definitions (Yukl, 2010).

Trust building and maintaining in organizations create basic vitality and energy that *enables* revitalization of individuals and organizations, and effective, profitable performance, accordingly. Vitality is energy of the will, emotions and actions. It can be seen in people's motivation, enthusiasm, as well as fully utilizing their different skills, abilities and talents. One example is taking people through a change process in which they are able to take risks while continuously facing the unknown and unpredictable. Trust gives birth to vitality and vitality strengthens trust. Practically speaking, it means courage and readiness to deal with different opinions and perspectives. Conflicts and tension in an atmosphere of trust can also produce positive energy which results in active interaction and courage to make a difference (vrt. Nurmio & Turkki, 2010).

If an organization's vitality is depleted or is not maintained, these "feeble" organizations face unfavorable development, and even crisis. The organization's overload or premature aging can lead to its impotence (Probst & Raisch, 2005). This can be a result of overheated growth speed or respectively of slowness, in other words, of strong change resistance, clinging to old ways or the restrictions of a stiff culture. Conversely, the culture of trust is characterized by a readiness to follow and manage work environment, growth, and the operation structure of the leadership. It also means flexibility in facing changes, making decisions and maintaining an ability to function in a suddenly and unexpectedly changing environment. It takes creativity and flexibility to apply new ideas and decisions. A willingness to take risks is intrinsic for trustfulness. It can empower the organization to success just in a time of great uncertainty. When people trust their colleagues, their energy can be focused on the core activity, development, and performance instead of games, politics, and control.

In summary, trust building serves as influencing power and a device for leadership. It can give work places vitality and competitiveness, with which the future business life copes in the world of concerted, multicultural, and diverse global competition economy. Changing leadership requires new, deeper awareness of the significance and the necessity of positive influence in mutual interaction. It also includes an awareness of the effects of one's own actions, e.g., of trustful vs. distrustful actions. Continuous change also requires for leadership to have fresh understanding and new efforts to remove national, organizational and cultural as well as leadership obstacles from the way of trust-based leadership.

Trust building - a new focus in leadership

Trust in leadership work is embedded in the relationships between leaders and subordinates. Leadership by trust can be defined as a *leader's ability to enable interaction, co-operation, and productivity* (Savolainen, 2011). Enabling is central in this. It means both the removal of obstacles and supporting new ideas, solutions and implementations as well as inspiring and encouraging them. This is *the new focus of leadership.* Trust in leadership work aims at achieving functionality, co-operation, and performance in organizations. Trust grows in the soil of interaction and openness and can give birth to well functioning relationships between individuals, groups and networks. In everyday leadership, trust

provides readiness and ability for social influence. In daily work, it is shown in trustworthiness.

Work relationships are ever more important in a global expertise-based economy because creating new knowledge and innovation as well as development of competitiveness require them (Nurmio & Turkki, 2010; Savolainen, 2009). Leadership is currently undergoing major global transformation. Consequently, the significance of trust in leadership is inevitably connected to a larger change of working environments. For this reason the prerequisites of trust are highly emphasized. Intangible, human capital specifically makes a strategic skill resource in competition. Thus its conscious management is more and more important. In service economy, the goal is to increase interactive relationships and develop systems of co-operation. The challenges come from creating, sharing and interpreting knowledge.

As working life is facing tremendous changes, business models and relationships focus more and more on balancing and controlling the tension between competition and co-operation. The lack of managers weakens conditions and opportunities for interaction. That affects the level and maintenance of trust. The effects are also seen in an organization's openness and atmosphere as well as the motivation and commitment of the people. The benefits, effects, and results of trust are portrayed in the frequency and effectiveness of communication and interaction. This in turn is reflected in the practice of creating and sharing knowledge (Savolainen, 2008). In the end, the benefits are realized also in performance and results.

Because of the above mentioned changing factors it is reasonable to emphasize trust, and develop means to facilitate it in organizational leadership. The challenges of intangible capital renewal in a global scale are tremendous and they are primarily leadership based. Leadership does need renewing because many macro level factors influence the everyday activities of individuals and organizations. These are multiculturalism, environmental issues and technology among others. As a result operations are ever more complex, unsecure, and harder to control. Thus a sense of security is needed to maintain a capacity to deal with uncertainty and change. It is trust-oriented leaders that are needed to coach more teams in order to maintain and renew productivity and competitiveness as well as well-being and continual vitality.

The new kind of leadership seeks its role, because leadership cannot function any longer solely through an individual, position, or hierarchy. New competences and resources through which a leader gains his or her right to lead must be discovered and developed. Trust is a way of influence, which helps to build mutual co-operation and productive operation. Still, the manager's role is significantly more influential in how the subordinates want and actually do perform and what kind of results are achieved. Subsequently the subordinate influences the way he or she benefits the organization and how dependable his ability and performance are to the manager.

Trust building faces challenges

Trust building and maintaining are challenging at work places because so many situational factors influence them. Among the most common ones are *cultural structures* like deep convictions and customs as well as hindrances in communication. Trust is reciprocal and

cannot form one-sidedly. Trust "belongs" equally to each member of the work community or network. Everyone owns an equal part of it and is responsible to build it. It can be build upon the process and recommendations of good professional behavior. The significance of trust is emphasized in fields requiring creativity and innovation because they require freedom and favorable attitude and environment. Creativity never happens by force but in *freedom*. It develops through hearing different perspectives and views, freedom of discussion, and accepting differences. Creativity or trust for that matter do not happen in communities where there is room for only single opinion, view, truth, or interpretation. In large, multi-level and multi-unit organizations internal communication from top down is a very simple, everyday example. The content of electronic memo with instructions, schedules, and goals does not necessarily reach the target audience. It may not be understood, because the person receiving the information does not have a chance to interpret or check it. Electronic information overload may be a reason: one does not get answers, messages are ignored, or it is impossible to reach the right people.

In current business management, complexity is the approach characterizing daily operations and leadership. In intricate organizations varying views are crisscrossing, which manifest in contradicting interests and objectives. They are not accepted or dealt with in *fear of conflicts*, which is also an indication of the nature of culture and leadership style and the need for them to change. Human intellectual capital is renewed in complex and conflict situations - on one hand in interaction and on the other hand in simultaneous cross-fire of contradicting views and objectives. Conflicts and differing views, however, are strength, because they can produce constructive dialogue and profitable performance.

Furthermore, trust building and maintaining requires an investment in leadership capacity. Education is indispensable to gain skills. Intangible capital, like knowledge or trust can grow or disappear just like financial or other kind of capital. Despite of the fact that organizations aim to increase (tangible) capital which can be measured by financial indicators, strengthening co-operation between actors is among the most important attitudes and means to renew and increase internal, intangible capital.

Leadership role in renewing human intellectual capital

Especially in knowledge and expertise based operation in which critical assets are intangible, the leader cannot base his/her authority anymore on management position. Authority is rather based on the expert-subordinate's desire and ability to claim his status through being allowed to influence his own performance. Leadership has become emergent and has to be 'earned'. In the success of expert-based organizations this is a central factor. At this time trust and authority are re-evaluated. The organization's sources of authority are diversified and leadership is shared. The authority of an expert-subordinate is based on knowledge and know-how, while the authority of the leader is based on position, knowledge and ability. What happens if a manager lacks core competence required in leadership? How will position-based leadership work and influence the followers? If the manager wants to be trustworthy, competence cannot be disregarded.

Essentially, leaders are responsible for knowledge, guidance, motivating and commitment as well as creating a culture for learning needed for the renewing of human intellectual capital.

Gaining competence as well increasing performance and continuous individual development are reached through human intellectual capital. That is why ability-based management is central for strategic human resources. Human capital is both individual and collective. When the focus is in individual competence and ability as well as creativity and innovation, these qualities specifically are in demand in the information age. The ability to lead human capital is an important competitive factor for an organization. Knowledge may be unique or general but new knowledge is not created without encouraging creativity and innovative applications. This requires good leadership. The timeliest challenge in renewing human intellectual capital is thus renewal of already attained knowledge and ability.

When the understanding of intangible assets increased in the 1980s, it was observed that the organizational performance was greatly affected by its intangible capital (Sullivan, 2000). As a result, intangible capital began to be seen as an important issue in leadership. After Stewart (1997) defined intangible capital as mental, human and intellectual asset, it impacted the theories and practices of providing leadership for knowledge and know-how. From the point of view of leadership, it is important to understand human capital as multidimensional combination of mental, structural and relational resource (Edvinsson & Malone, 1997) that are also interrelated. While human capital is comprised of values, culture and philosophy, human capital also gains an organizational level character. It is easier for the leadership to influence the internal than external structures and relationships. Leadership is an internal structure but it influences the external relationships for example in customer relations management. Practically, the effects and connections can be seen for example in developing personnel's customer-based know-how. Thus human capital requires and utilizes interchangeably other intangible capital (Stewart, 1997; Roos & Roos, 1998).

Creating human capital is an integral part of an organization's leadership process. It describes activity, customs and processes (Roos & Roos, 1998), with which intangible capital is created for the benefit and success of an organization. Stewart (1997) points out the differences in leadership between different types of intangible capital. Different types of capital require varying leadership styles and. Taking care of knowledge and ability is central to the renewal of human intellectual capital. It is important that individuals and organizations are going in the same direction so that individual human capital would benefit the organization. Leadership is essential in this as vision, mission, and strategy direct the development.

Trust in renewing human intellectual capital

Because the organization is built upon the people and their talents as well as their knowledge and expertise the relational resources essential for trust formation are created by human activity. Generally, what is meant by relational capital are an organization's external relations to interest groups, such as customers and journalists. However, relational capital is more multidimensioanl than these, because it implies also internal interaction and relationships. This has not been specifically emphasized when evaluating relation-based intellectual capital.

Research shows the connection between trust and organizational performance (McEvily et al., 2003). Dirks and Ferrin (2002) studied the impact of trust on how talent, knowledge and

expertise are utilized in their full potential in an organization. According to their empirical research covering 40 years, trust plays an important role in the employee attitudes and behavior. It is seen in more positive work attitudes as well as in a willingness and ability to co-operate.

From the perspective of leadership by trust intangible capital is immaterial, governed by the organization, based on individuals' knowledge and know-how, capital created by internal and external interactive relationships, which add competitiveness in the market (Edvinsson & Malone, 1997). It includes individual process as well as cultural and operational structures which support the activities of groups and individuals. Among these are organizational structure, deep-rooted ways of operation and leading. Knowledge creation and sharing form the key processes in renewing human resources. Hence, trust provides a strong potential for renewing human intellectual capital. Therefore, it is worth nurturing and preserving. Trust has similarity to tacit knowledge because it is very unique personal knowledge and know-how and is embedded in relationships. Trust facilitates managerial routines, for example, sharing of information and knowledge. They manifest themselves in a positive, open behavior and communication.

Renewal of intellectual capital for competitiveness

The renewal capacity is a quality in the organizational management and HRM, which manifests in its procedures and processes. It is an ability to implement strategy and respond to changes. Currently, competitiveness is based on quick capacity for renewing and effective usage of opportunities and capabilities that are mainly human and intellectual. It is noteworthy that individual human capital may also include inherited and personal character traits such as intelligence, flexibility, and relatively consistent temperamental characteristics such as openness or introvertedness. These factors are relatively permanent, and usually cannot be much altered or developed. However, they may be foundational and important prerequisites for renewing and development of human intellectual.

Mobility of the work force is phenomenal in the global context. Kong & Thomson (2009) have found out that personnel and human capital are not as effectively and easily mobile as has been expected. Therefore organizations should create other means in their human resourcing, especially in addition to recruiting, to develop and include human capital for the sake of securing competitiveness. Häkkinen & Savolainen (2008) argue that mutual trust secures the effective use of know-how and expertise. This is an important observation for the sake of leadership because the effects of lack or failure in leadership can be serious and fatal for the organization's performance. There are examples of this in studies among crisis companies (Probst & Raisch, 2005). According to the researchers a too strongly centralized leadership structure can lead to the failure of a company or an organization.

To improve competitiveness more attention should be paid to maintaining trust than is done presently. A good example of trust building is personnel's job orientation. Häkkinen and Savolainen (2008) report on initiation in their study of trust in fresh leader-subordinate relationships. Job orientation is seen as one of the routine activities in HRM. The new staff member emphasized the significance of job orientation as a valuable and unique opportunity and situation for trust formation. When the newcomer is introduced to positive

interaction and sharing of information from the beginning, at best it leads to effective learning and socializing. It also becomes easier to apply good examples received in the orientation to one's own work. In the opposite situation when the initiation to work and organization is done poorly, consequences are mostly negative. The worst for the organization are underachievement and prognosis of lower performance. When know-how is not utilized from the beginning, or when a good example is not given of open knowledge sharing, the practice becomes permanent. Unfortunately this practice is often transferred to elsewhere in the work place.

EMPIRICAL FINDINGS AND EXAMPLES FROM CASE STUDIES

The practices of enacting on trust in leadership are presented next. They are based on the findings from the qualitative studies. The case study data were collected from the private sector organizations running business both in the service and industrial sectors, more specifically trade, retail, construction engineering, ICT, and metal industries (Malkamäki, 2010; Savolainen, 2008, 2009; Havukainen, 2011). The studies represent examples of trust development between actors and organizational units, trust in knowledge sharing and leadership. The aim of this section of the paper is to advance understanding of the role of trust in organizations and leadership, and present the ways of enabling and supporting organizational innovativeness.

Two case examples are presented and brief references made to the preliminary findings of the third case.

- Case A: Trust development within internal customer relationships between two organizational units and actors in a Finnish trade organization (Malkamäki, 2010).
- Case B: Knowledge sharing, trust and renewal of intellectual capital. From the service sector, a small Finnish construction engineering company (Savolainen, 2008, 2009).
- Case C: Trust and tacit knowledge in leader-follower relationships. A study of three companies in different industries (work in progress; Havukainen, 2011).

Case A – Trust building between organizational units and actors

Case company and methodology of the study

The study focuses on how two different functional units within a large, multi-unit and fast growing trading organization build mutual trust. The company has a wholesale unit and 69 retail sale units employing about 3900 people in all. In 2009 the net sales was 595 M€. A qualitative case study was made and the empirical data was collected by thematic interviews. A qualitative case study approach was chosen, as the research topic requires understanding the company holistically in the real context (Koskinen et al. 2005, 154). In the study, 'a case' refers to the leaders interviewed at different levels and positions by face-to-face interviews. The data consist of the individual interviews of six middle-level leaders. Leaders' perceptions and experiences of trust development were examined within internal customership between two units and through the concepts of customer relationship

management. The content of the transcribed data was analyzed using a thematic method and interpretation was theory driven.

Key findings

The key findings show that trust developed primarily towards the organization in the case organization. Yet, trust between people was also considered important. One of the main findings is the importance of the strategic management system in trust building between organizational units. Shared goals, clear allocation of responsibilities, as well as defined policies and procedures form the basis for productive and predicable co-operation. Transparency in leadership, based on management system, sharing of information, and control were seen as the most important pillars of trust building.

Interaction is an important element of cooperation. Electronic communication is the dominant tool for it, but direct interaction is also needed for sharing understanding and meaning. This research finding is supported by both customer relationship management and trust research literature. Moreover, a kind of unexpected finding that came up in the data was the importance of transparency and control in trust building, which differs from the views of the mainstream research literature (Malkamäki 2010, 92). More specifically, the literature is quite unclear on the point of control and trust. From a contextual-based approach it is suggested that the relationship between trust and control can be either complementary or substitutive in nature depending on the type of control (Das and Teng, 2001, quoted in Costa & Bijlsma-Frankema 2007, 398).

In this study, control and trust seems complementary. When all the members in organization are required to follow the rules and agreements, and the actions are controlled, it makes people to feel justice and equality in procedures. It is an important notion that the forms of control and procedures may vary but trust seems to develop despite of the variation (Malkamäki 2010, 93). This is supported by Costa & Bijlsma-Frankema (2007). Trust cannot be a control mechanism, if both trust and control are defined restrictively and not for increased clarity. Trust is defined as a positive expectation about others motives, and control as the process of regulating others' behavior to make it more predictable (Schoorman et al., 2007, 508).

Further, the findings reveal that time and forms of cooperation have an effect on trust development. Trust between actors not known well is seen more as trust in organization. Therefore, trust may not move into the deeper level towards the identification stage. Hence, structural and operational issues have a significant role in trust development in organizational level. As a result of the current study, setting goals and sharing them, and the management system supporting the common goals are the basic strengthening elements of trust. Interaction, knowledge sharing and business developments together are seen as glue between partners. *Transparency and control* are linked to the predictability. They are pillars of trust and trust building. An opportunity to be a mentor or an actor in the process of knowledge sharing is a tool for e-leadership. Trust building is strongly related to changes in the leadership system and especially in values and organizational culture. The findings thus suggest that the management system is an essential 'corner stone' of trust development. Organizational structure and systems support cooperation needed for reaching goals and

purposes (Malkamäki 2010, 92). The basis of trust is strongly based on *the functioning management system, organizational culture* as well as *structures and processes* by which it promotes development of trust in interpersonal relationships.

The results also seem to emphasize the significance of the management system as an antecedent of trust in leadership. The findings suggest that common goal setting, competence, reciprocity and predictability are the common features of trust building in leadership work. Furthermore, the experience of success enhances trust development (Malkamäki 2010, 89; see also Häkkinen & Savolainen, 2008). In leadership, the finding of the management system-based trust shows how transparency and control enabled and facilitated the clear distribution of work, power and responsibility issues, documentation practices, common goal setting and sharing, following performance indicators and information system with using intranet.

For interaction between actors in the units meeting practices and giving and receiving feedback are the concrete tools of cooperation and trust building, by which the attitudes can be changed. Change occurs through constructive feedback in interaction. Predictability by transparency and control strengthens trust, especially in the beginning stage of trust development. Time is needed for trust to be built and develop. Trust has to be earned and it is based on the experience of cooperation. The reciprocal following of rules and agreements create trust. Experienced fairness and equity by transparency and control are the key elements of trust building. In interaction, hearing, giving and receiving feedback and taking them into account in practical improvements facilitates trust development. In changing leadership, the leader's role as an example as well as keeping promises play an important role in creating trustful relationships (Malkamäki, 2010).

Conclusions and implications

Based on these findings of the specific organizational context, the inter-relation of trust at different levels seems worth further theoretical discussion and empirical studies. The interesting finding of the dynamics of trust development shows how trust develops simultaneously but differently depending on the levels, frequency of interaction, and time needed or available. Just as perceptions about an individual's ability, benevolence, and integrity will have an impact on how much trust the individual can garner, these perceptions also affect the extent to which an organization will be trusted (Schoorman et al. 2007, 345).

Trust is based on acquaintance but the study shows that in more complex organizations trust is built by the norms, reciprocity and networks (Koivumäki 2008, 80). In this case, trust development is based on the principle of reciprocity included in *the management system*, and the rights and the responsibilities of actors. The cooperation and interaction procedures in the target organization vary depending on the managerial level. Regular, individual interaction between actors of the other organizational units is restricted at the lower levels of organization. Therefore, in trust building, the quality of relationship between leaders and followers is linked to the organizational level in and between organizational units and actors.

In the study, trust formation in internal customer relationships between the units seemed interesting and worth further examination. It is even more so, as the inter-relation between the actor level, (inter-personal) and organizational level (inter-unit/organizational) trust emerged. Finally, the findings imply that the role of trust needs to be understood more deeply in 'coopetitive' type of relationships which may be multiplex in inter-personal, intra- and inter-organizational contexts.

The study increases understanding of how organizational level factors and inter-personal relationships between actors are intertwined by revealing differing developments by the levels. The findings imply that currently under-researched area of multi-level trust development (Rousseau et al., 1998) is what further research may need to look in real life cases and relationships processually and contextually.

Case B – Knowledge sharing, trust and renewal of intellectual capital

As important as tacit knowledge is for gaining competitive advantages for organizations, it is elusive in nature and, consequently, tends to remain inarticulated; It is difficult to understand, observe, acquire and share, and diffuse in the organization. In the conceptualization by Nonaka and Takeuchi (1995) of tacit and explicit knowledge, explicit knowledge is defined as easily identifiable, easy to articulate, detain and share. It is in written forms such as books, manuals and reports, etc. Tacit knowledge is defined as consisting of intuition, feelings, perceptions and beliefs. It is deeply embedded in the ways of thinking, talking, and working, and in relationships. It is complicated to articulate and express. Hence, it is difficult to convert, transfer and share between people. Due to the nature of tacit knowledge, people need good grounds, motives and support for sharing. Leaders are key supporters of sharing. Organizational culture and leadership form a foundation for people involvement and willingness to share knowledge.

That is why the examining the real life practices of sharing tacit knowledge is important This is also the point for presenting the empirical findings in the paper. The entire idea to studying the trust and tacit knowledge sharing is briefly: *unless shared tacit knowledge is not converted to explicit*. Trust develops and is embedded in relationships which enable discussions and sharing of ideas & knowledge between people. By definition tacit knowledge is shared trough people and is a social process.

A largely knowledge-based expertise in work today involves the acquiring, creating, sharing and utilizing of knowledge in groups and between individuals. This also comprises interactive practices, i.e., communication and coordination. They may specifically reveal how trust has been used in an organization as a human 'talent' and intangible resource. Only if each party invests in trust, the organization will benefit. Nahapiet & Ghoshal (1998) state that it is in the everyday routine of both leader-follower relationships as well as other work relationships where the skills to create and share human intellectual capital will be manifested. This is especially apparent in interaction and thus is behavioral-based. That is why a relationship perspective is so essential. In the renewal of human intellectual capital trust is thus a relational competence which on one hand enables creating, renewing, utilizing and sharing knowledge through interaction, and on the other hand strengthens and

maintains the cooperative relationships at the work place through interaction and continuous social activity.

In the context of project work, trust is seen as an important antecedent for collaboration in a project group. It should be noted, however, that although trust may frequently lead to cooperative behaviour, trust may not be a necessary condition for cooperation to occur, as cooperation does not necessarily put a party at risk and as mentioned above risk taking seems characteristics to trusting one another. Absence of trust in a project group, on the other hand, leads to seeking protection from risks and to tightening control with higher bureaucracy. Project culture provides opportunities for informal interaction between group members and for reinforcing the sharing of common values. This strengthens tendency to sharing tacit knowledge (Koskinen, 2001). Trustful working environments are mentally open appearing, for example, as appreciation of one another's expertise (Huotari et al., 2005), and also physically open, e.g., open-office lay outs.

Case study findings from a small construction engineering company

Methodology, data, and the case company

The second case example examines the role of trust in developing intellectual capital which involves largely the sharing of tacit knowledge in a project-based organization. What are *the factors related to and having influence on* the sharing of tacit knowledge (Savolainen 2009, 2008). Qualitative methodology was selected giving the scarcely studied topic and the purpose to gain more understanding of the abstract topic (Yin, 1994; Eskola and Suoranta, 1998). The case company's operations are entirely performed in projects and project groups. The company is a small construction engineering company with 19 employees in all focusing on structural design. There are approximately four project groups working in the company at the same time. The combinations of the groups may or may not vary between projects. Projects may last from 6 months to over a year.

The case study data was gathered by in-depth interviews. Six project workers were interviewed including a project manager. They formed a project group. Them interview method was used. All interviews were recorded and transcribed. The interview data was analyzed by thematic analysis of the content of interviews. The analysis was theory-driven based on the theoretical framework.

Key findings

Tacit knowledge is shared by several *methods.* Six main ways emerge as follows: interactive, verbal advising, modelling, joint problem-solving, guiding to learn, job enrichment, and initiation into the company. On significance of initiation in building trust with new employees see Häkkinen and Savolainen (2008).

Organization- and individual-related factors affect all of the stages in the process of sharing knowledge. They seem to appear in combination and as a whole. Sharing of knowledge is a chain of events starting from the identification of key knowledge needed and the individual needing knowledge, and proceeds to choosing methods of sharing. Sharing and receiving

knowledge occur in personal interaction and proceeds with utilizing of knowledge. Finally, internalizing of knowledge occurs if *willingness and motive* for knowledge storing on the individual's personal knowledge base exists.

Trust appears specifically in the functioning of group relationships and dynamics. The findings show that group relationships and managing group dynamics turn out to be the key antecedents and critical capabilities even for other elements of tacit knowledge to appear and evolve. Ability to collaborate and the functionality of relationships have an effect on daily work, success of projects, and goal achievements accordingly. Individuals can have influence on this by creating and sustaining the relationships in the project group through their behavioural choices such as keeping the 'deals' and promises, among others.

Summarizing the key findings

The results reveal four *forms* (types) of tacit knowledge:

- professional knowledge (sound expertise and quality of work)
- management of group dynamics (interaction skills and ability to collaborate)
- management of entities (ability to see the essence and relations between parts), and
- management of knowledge resources and knowledge base (recognizing and meeting the need for key knowledge).

A uniting factor for these four elements is *experience* and its importance in the evolvement of tacit knowledge. Tacit knowledge, evolving from experience, becomes evident as sound and fluent practical capability.

Tacit knowledge is *shared by several methods.* In practices of sharing six main ways emerge as follows: interactive verbal advising, modelling, joint problem-solving, guiding to learn, job enrichment, and initiation into the company. Havukainen (2011) has found out that the organized sharing of tacit knowledge involves practices and procedures such as mentoring, work in pairs, tutoring, sparring, and benchmarking. Moreover, stories and narratives are important and influential forms of sharing. E-mail is perceived as a 'hard' and straight forward form of conveying knowledge. Yet, tacit knowledge sharing is made through the electronic channels.

Tacit knowledge sharing occurs in an interactive *process* between group members. A personal, individual nature of the assimilation process of tacit knowledge is presented by Havukainen (2011). Several individual- and organization- & management-related factors are discovered that affect the sharing of tacit knowledge in the case company (see Figure1.)

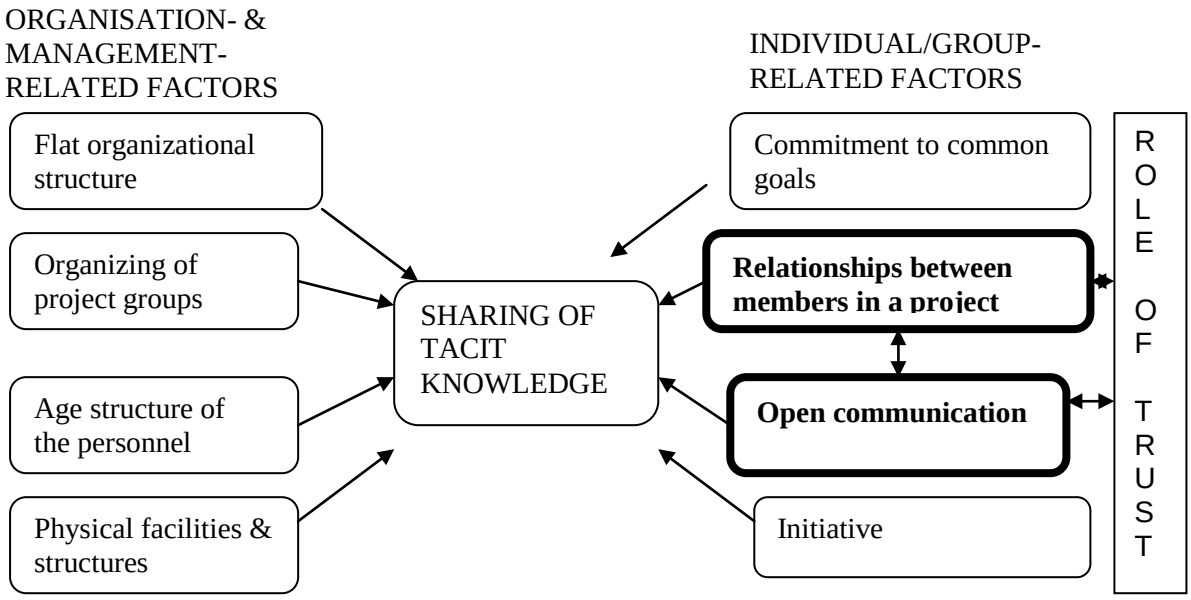

Figure1. Trust and factors related to the sharing of tacit knowledge in the case company (adopted from Savolainen, 2008, 2009).

An interesting finding is the dynamics of sharing; a process beginning by identifying the nedd for key tacit knowledge and the person in need for knowledge. The process proceeds from choosing appropriate methods and ways (tools) all the way into the actual sharing, receiving and possible internalizing of the knowledge in question. The processual nature of sharing has hardly been made explicit in prior studies. Interpersonal trust seems important. Trust supports the intra-organizational relational system where trust-based relationships are formed and maintained. This facilitates the actions of sharing tacit knowledge.

Conclusions and implications

The findings show that trust facilitates the activity of sharing tacit knowledge. The outcome is seen in work quality and performance. Creative project culture (cf. Koskinen, 2001) seems pervasive to the company studied. It becomes visible in multiple methods of tacit knowledge sharing, and the development of human intellectual capital, i.e., individuals' skills and knowledge. Leaders play an important role in skills and knowledge development. In conclusion, the group dynamics and workplace climate seem the most critical factors in sharing of tacit knowledge (see Figure 1.) They are shown by open communication and commitment to common goals, and functioning relationships between group members in a project group. Trust has an impact on both group dynamics and workplace climate. In practice, trust appears e.g, in a frequency of interaction, communication, keeping the deals and promises, and guidance to learn.

In conclusion, it is important to understand the role that interpersonal trust plays in the process of sharing tacit knowledge. As for trust in sharing knowledge, most of the issues and challenges related to sharing that emerge from the data are related to challenges of

interaction between people and dysfunctional work relationships (including preliminary findings from the third case; Havukainen, 2011). Trust creates openness and freedom and slackens control. It could be a more powerful intangible asset for collaboration and renewal of human capital - provided that knowledge is shared. Cooperation reinforces good workplace climate and makes knowledge sharing more effective. This improves operational work quality and performance in project-based organizations.

The main *implication from the case B* to managers is that trust is needed for developing intellectual capital and innovative 'spirit' in the group work. Leaders should especially pay attention to the maintaining trust in work relationships so as to assure functioning group dynamics. Leaders can build trust and support project groups by their openness and encouraging interaction and to developing communication skills. Moreover, supporting the sharing of tacit knowledge requires improving of leaders' skills, too. This means social and communication competencies for creating trustful working atmosphere and open culture. In daily practices, leaders should also communicate informally. They could show trustworthiness by small daily deeds through competence, fairness and credibility, among others.

Summary and managerial implications of the cases

Findings from the case studies show that trust in the organization and inter-personal relationships is important in utilizing intangible human resources, competences and professional expertise in an effective way. One of the interesting findings is that the functioning management system strengthens trust between organizational units (Malkamäki, 2010) and builds trust between actors. It is about transparency in leadership with regular sharing of information. Shared goals, clear allocation of responsibilities, as well as defined policies and procedures form the basis for informative, productive and predictable co-operation. Transparency in leadership is seen one of the most important pillars of trust building and occurs through the information management system and on the appropriate degree of control.

In tacit knowledge sharing the findings show that trust plays a main role in the group dynamics and functioning relationships between individuals in a project group (Savolainen, 2008, 2009). Moreover, trustful workplace climate characterized by open communication is the most critical factor affecting the sharing of tacit knowledge. Tacit knowledge in project groups is based on the individual's professional experience and knowledge base. As it is complicated to transform into explicit and share, the functioning relationships between group members are extremely important.

The case study findings imply for leaders that a transparent management system is important for trust, leadership and developing intellectual capital in which knowledge sharing plays an important role. Further, essential for leadership by trust is to enable, develop, and maintain work environments that nurture innovativeness. In other words, open culture and trustful climate support functioning relationships between actors and strengthen trust. This way social environment develop where innovativeness may grow and become prosperous. The practical implication for group leaders is how important it is to develop communication skills and functioning group relationships. In daily leadership work,

it is the small deeds that make a difference in leading with trust - not the great promises! Finally, concluding by Hamel (2007, 97) ”if the organization wants members to trust each other in all issues at the workplace nothing should be kept secret.”

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LEADERS`S UNTRUSTWORTHY BEHAVIOUR DECREASES INNOVATIVENESS OF FOLLOWERS: WHAT KIND OF LEADERSHIP ORGANIZATIONS NEED TO ASSURE THEIR INNOVATIVE DEVELOPMENT?

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ABSTRACT

This paper examines trustworthiness in leadership behavior as an inspirer of innovativeness. In managerial leadership, ensuring functioning new innovations is one of the major challenges in more and more complex organizations and competitive environment. While new innovations for all different kind of business fields from industry specific few to the education and consulting companies are found to be obligatory for organizations to catch on, is intra-organizational trust and leader`s trustworthy behavior as obligatory for succeed management, more specially managerial leadership. This research has been made by using qualitative methods.

Keywords: Trust, trustworthiness, managerial leadership, effects of trust, distrust, innovativeness, qualitative method, triangulation

INTRODUCTION

Trust forms a foundation for co-operation and is part of a social moral order in organizations and society (Rousseau et. al., 1998). Trustworthiness seems to be 'earned by daily deeds' and ways of actions of leaders (Häkkinen et.al.,2010). Trust has been shown to have influences on processes such as communication, cooperation, and information sharing (Burke et.al., 2007). Innovativeness is usually mentioned as an organizational behaviour. In this paper, innovativeness is discussed at individual level, which might be destroyed or harmfulled by leader`s distrustfully behaviour in leader-follower relationship in organizations. Distrust as a construct have been theorized as unidimensional or different construct from trust, and defined as low trusting or negative expectations of the other party and with a lack of confidence in the other, and belief that the other may not care about the other's welfare and may act harmfully (Lewicki et.al.,1998). Although trust has been widely studied in inter-organizational relationships recently (Ebert, 2009), the intra-organizational trust perspective is more scarcely studied despite the fact that it affects also the functioning and dynamics of inter-organizational relationships (Savolainen, 2010). How are these two perspectives interrelated? Recent research has called for research on trust at both the macro and micro levels (Schoorman et al. 2007). In this paper, at macro level trust is represent between organizations and at micro level trust (which is main topic in this paper) is represent between leader and follower. More specifically micro level trust is shown as a *trustworthy behavior*. Trust is a complex, multifaceted phenomenon, and different conceptualizations of the nature of trust exist in interpersonal relations (Möllering et.al.,2004).

Leaders show trustworthiness by building and sustaining or violating trust (Häkkinen et.al., 2010). The effects of leader trustworthiness are presented and discussed based on two real

life cases from small industrial companies. Both companies represented different kind of leadership styles; other might be describes democratic and the other authoritarian. In conclusion, the findings confirm the results in prior trust research that leader's competence (ability) is one of the key dimensions of trustworthiness (Peterson,1998) as well as leadership style. Findings show that the process of trust development is complex appearing as more meandering in nature. Tillmar (2007) conceptualizes trust and distrust as the endpoints of a continuum. Research results indicate, that when distrust exists between leader and follower, the follower has no interest to create new or develop itself or its work neither than feel innovative. Trust might also imagine as a "house with many doors", when it is possible to open a new door and going forward ignoring the disappointments; moving on. I might hesitate how far human might go without breaking down and giving up to even try to trust anymore? Every door you open, that heavier it will be to open the second one.

The study also shows that leadership style makes difference to innovative atmosphere at the organization. The style of management-by-fear broke the opportunities for developing and keeping quality and innovative workforce (Savolainen & Häkkinen,2011). Distrusting employees do not work effectively and share their knowledge, and tacit knowledge in specific (Savolainen,2008), which is extremely harmful for innovativeness atmosphere in organizations.

Methodologically this qualitative research is implemented by using triangulation. Narrative analysis, interviews and observation methods are combined in the study. Qualitative research methods have challenged to trustworthy development and leadership influences for subordinates and organizations (Cho & Ringquist,2007).

THEORETICAL DISCUSSION

Trust, Distrust and Trustworthiness

Trust has been classified in business research as an intra-organizational trust and an extra-organizational trust. Trust in different organizational and business relationships has been examined widely and multidisciplinary over the last few years (Ebert, 2009). Inter- and intra-organizational trust has been seen as a basis for all relationships and business interactions. Rotter (1967) defines *interpersonal trust* as an expectancy by an individual or a group that the word or promise (verbal or written) of another individual or group can be relied upon.

The importance of trust in leadership within organizational contexts has been recognized in the literature. Trust has been shown to have influences on processes such as communication, cooperation, and information sharing (Burke et.al, 2007, cf. Shamir& Lapidot, 2003). Distrust as a construct have been theorized as unidimensional or different construct from trust, and defined as low trusting or negative expectations of the other party and with a lack of confidence in the other, and belief that the other may not care about the other's welfare and may act harmfully (Lewicki et.al, 2006, 1998). Trust has been seen as a one of the main element of productivity in organizations (Bijlsma & Koopman 2003). In continuous change occurring in organizations, trust plays an important role in improving work welfare and business success (Seretin 2005, Mishra 1996). Innovativeness and good work welfare are walking hand-by-hand. Commitment to work and organization, and mental

well-being are related affecting the success of the organization. In this trust plays also a role (Coyle-Shapiro et. al., 2002). Commitment of employees is shown in acceptance of company values, pursuing goal achievement, and pride of working in the organization and willingness to stay (Coyle-Shapiro et. al., 2002). Trust appears at many levels, organizational or managerial, and is manifested in interaction between employees and/or organization (Joseph & Winston 2005, Serva, Fuller & Mayer 2005). At the organizational level trust is described as faith in the engagements of the employer. Employees believe that the actions of organizations are performed for public interests eventually (Lee 2004, Gilbert & Tang 1998). The more engaged followers are their work, that better they share their knowledge and innovative ideas to company`s credit.

Mental insecurity may be often a reason for atmosphere- related problems in workplaces such as teasing, conflicts, disputes and arguing. All of them affect the level of trust. Mental well-being is largely sustained by emotional support (appreciation, respect, openness, feedback, etc). Correlation of commitment for work and organization is reflected in employees work motivation and satisfaction, i.e., work welfare (Häkkinen, 2007). Leaders support is expected and their actions are seen as the most influential. In co-creation, trust is a basic element of functioning relationships in organizations (Savolainen, 2008). Employees in organizations create *trustworthiness* by their actions and behavior. Trust building has been listed as one of the most essential tasks in managerial leadership (Graen & Uhl-Bien 1995, Yukl 2010). Trust building and maintaining is complex, however (Ikonen & Savolainen 2010, Nurmio & Turkki 2010). Leader traits and behavior including styles and skills matter in *trust building.* By implication leaders mundane behavior seems to play the main role, i.e., trust is built and maintained by leaders 'daily deeds' (Häkkinen & Savolainen, 2010, Savolainen, 2009). Theoretically, various leader traits and leadership styles are related to trustworthiness shown in practice by the leader's behavior in dyadic subordinate-leader relationship. In conclusion, trustworthiness matters in emergent leadership (cf. Yukl,2010).

Managerial leadership and innovativeness

Theoretically, various leader traits and leadership styles are related to trustworthiness shown in practice by the leader's behavior in dyadic subordinate-leader relationship. In conclusion, trustworthiness matters in emergent leadership (cf. Yukl,2010). Leadership, management and managerial leadership, couching leadership etc., are often mixed metaphors. Northouse (2004) descriptive leadership as to explain how leaders help organizations to reach their purposes through concern for production (which is generally named as a *management)* and concern for people *(leadership*). Additional confusion for the term *leadership* is caused by the use of other imprecise terms as power, authority, management, administration, control and supervision to describe similar phenomena (cf. Yukl, 2010). Leadership includes following concepts: other term is management, reference to the past and future, dealing with change and managing stability, symbol of responsible and power, and also process of influence. Managerial leadership retains both terms: management and leadership, which means that processes and people will be lead at the same time. (Avery, 2004)

Innovative leadership or leading innovativeness retains those dimensions of leadership and for that reason, could be understood as a managerial leadership point of view. In the

development of trust and distrust in the organization, organizational culture is depicted as 'the other side of the coin of leadership' and is largely influenced by leaders' actions (Schein, 2004). In the case of very authoritarian management style, for example, employees become socialized into and adopt the way of actions of their leaders. As an indication of trustworthiness, trustful atmosphere, spontaneous sociality emerges between organization members (Fairholm & Fairholm, 1999). In the opposite case, distrustful atmosphere prevails which hinders communication and interaction (Savolainen & Häkkinen, 2010). Poor leadership underestimates employees' competences, which destroys innovativeness.

RESEARCH METHODOLOGY AND DATA

Methods of analysis

This paper adopts an explorative, qualitative approach to the study of trustworthiness within leadership. In the study, interviews, observation and narrative methods are used. The data were collected by means of thematic face-to-face interviews, open-ended interviews and observations. A few team leader-follower dyads in two organizations have been interviewed and observed. Methodologically, and from the philosophy of science perspective, this qualitative study is based on the constructionist paradigm and multi-source data. Narrative analysis, method of narrative accounts as well as interviews and observations will be combined in the study. Qualitative research methods have challenged the studying of trustworthy development and leadership influence on subordinates and organizations (Cho & Ringquist 2007). This paper answers the challenge by qualitative and longitudinal type of study using several data gathering methods.

Description of case company

Both companies are SMS companies and well recognized on their own business field and economically bandwagon. New innovations and product development were obligatory to the lean manufacturer.

- Company A, the first case (thesis) company, manufacturing and sale of valves and pumps, operating in worldwide.
- Company B, the second company, vegetable food supplier which main customers include mostly professionals in food, restaurant and catering companies in Finland.

Company A- The leadership style was pretty authentic and organization composition very hierarchy. Middle managers had responsibility, but it was somewhat apparent; GM made all decisions after all and his behavior was not steady handed nor neutral or equitable toward employees. Open dialogue between managers and subordinates was not potential. Also fear and qualm for GM`s attitude existed among the people. Co-creation between employees through the organization was insignificant.

Company B- The leadership style was democratic and participative management. Atmosphere in the organization was communicative and open to debate. Flexible job descriptions provided for diverse work and limitation of liability as well as authority. Co-creation between employees and managers was trivial and matter of course.

Main findings

The study shows that the factors most influential to the trust between leader and follower are: First leader: 1) equal behavior toward all employees and avoid divide or separate them for groups. Also avoid create too close relationship between any subordinates. 2) Showing and being trustworthiness when behaving stabile all the time, standing behind the values and leading democratic. 3) encourage followers to share their knowledge by asking their opinions and respecting their points of view. Second follower: 1) Avoid group together modeling cliques or clans inside the work community. 2) Distinguish work from leisure when adopting attitude for co-workers and leaders; understand the relevant behavior at work. 3) Share their knowledge to all co-workers and let information flow for tacit knowledge.

Furthermore, the study suggests that the most important phases influencing the strengthening of trust are reciprocity between an employer and an employee, competence of both parties and increasing of responsibility. On the contrary, at the organizational level, trust is not necessarily mutual and reciprocal (Schoorman et al. 2007). In other words, leader trustworthy behavior and untrustworthy behavior has effects on the organizational level trust. (Savolainen & Häkkinen, 2010)

CONCLUSIONS

In conclusion, the trustworthy behavior by subordinates might implement work related behavior and high commitment for company and work. Conclusively it can be stated that perceptions of the dyadic leader-subordinate trust about each other's ability, integrity and benevolence has effect on the extent to which an organization can be trusted (Schoorman et al. 2007). Thus, it seems that organizational and inter-personal trust are inter-related. Based on the research results, it seems evident that trust cannot be build without continuous interaction with leaders and followers, which has reciprocal effect on the interpersonal and organizational level trust, which is obligatory for people`s commitment and free will to create new and share their knowledge for benefiting organization. Overall, the study increases understanding of trustworthiness in leader behavior, leadership style and the consequences of trustworthy and untrustworthy behavior at both interpersonal and organizational levels.

The two leaders make an illustrative case for untrustworthy and trustworthy leadership reflected in different kinds of leadership features and behaviors. Most importantly, the differences in the cases show the favorable and unfavorable effects of trust in showing trustworthiness; in the first case trustful climate with enthusiasm, high commitment and effective communication and knowledge sharing prevail. In the second case, distrustful atmosphere, fear, low commitment, and lack of collaboration activity, and knowledge sharing appear respectively. As to leader behavior, in the case of authoritarian management style, employees become socialized into and adopt the very way of actions of their leader. Culture develops with unwritten daily manners by the influence of the leader. Lack of respect and appreciation stimulates development of distrust (Fairholm & Fairholm, 1999). The study implies that managers should learn more of trust and develop behavioral skills for showing trustworthiness. This way they may become more conscious of the role and consequences of trust and distrust in their actions of leadership. The style of management-

by-fear broke the opportunities for developing and keeping quality workforce (Peterson, 1998). Distrusting employees do not work effectively and share their knowledge, and tacit knowledge in specific (Savolainen, 2008; Juuti, 1999).

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3rd Parallel Sessions

Thursday June 30, 2011
13:30 – 14:50

A3 – Customer satisfaction

A3.1 **Time to let go? Relationship termination in the consumer banking sector**
Dr. Ying-Yueh Su

A3.2 **Households electricity market in Slovenia: Liberalisation and implications**
Dr. Štefan Bojnec

A3.3 **Elements of space style and music style on the high aesthetic, emotional, experience quality and experience satisfaction study**
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A3.4 **Predicting consumer intentions to purchase green cars: An empirical test of competing theories**
Dr. Chi-Horng Liao

TIME TO LET GO? RELATIONSHIP TERMINATION IN THE CONSUMER BANKING SECTOR

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ABSTRACT

In recent years there has been a growing interest amongst both academics and business regarding business practices in Asia. There is a tendency that organisations are seeking to adopt relationship marketing with the expectation that it will help them retain customers and in so doing, deliver long-term and value-added customers. Relationship marketing aims to attract, develop, and maintain relationship with customers. Although many researchers point out that it should be considered to have long-term relationship with customers, companies have recognised the importance of relationship termination for saving budget and time in order to reduce the operation cost. Previous studies have indicated that when necessary, service suppliers should terminate relationships because not all customers are willing to engage in long-term and profitable relationships with banks. Senior bank staffs, from seventeen Taiwanese banks, were interviewed about their understanding and use of relationship marketing and their relationship termination strategies The aim of this research is intended to extend the understanding of the termination phase of relationship marketing within the consumer banking sector, especially with those relationships are not required on a continuous basis or one they have served their function. This research discovered that banks took more time to establish and enhance customer relationships, however, and at the same time they spend even more time in dissolving dysfunctional customer relationships. Banks also changes their service forms to reduce their operation costs. Moreover, banks may decide not completely terminated customer relationships but possibly continued to maintain guanxi with former customers.

Keywords: Relationship Marketing, Relationship Termination, Customer Relationship Management, Consumer Banking Sector, Banks.

INTRODUCTION

The concept of relationship marketing was first introduced to service marketing in the 1980s by Berry (1983). Since that, building long-term relationships with customers has created lots of interest among academics and practitioners, also in Asian (Leung *et al*., 2005; Adamson *et al*., 2003; Lee *et al*., 2001; Davies *et al*., 1995). Organisations have adopted this concept with the expectation that it will help them to improve profitability. However, relationship marketing might have not only been accused of being over-conceptualised and underdeveloped empirically but its appropriateness to all customers has been questioned (Colgate and Stewart, 1998; Fournier *et al*., 1998; Barnes, 2001). According business press reports, unprofitable customers account for up to 50% of some banks' customers (see for example, Ang and Taylor, 2005; Blömeke *et al*., 2010). In other words, many companies have faced the problem of having these unprofitable customers, so called of "the bottom of the customer pyramid" (Zeithaml *et al*., 2001), are often inactive in terms of buying behaviour and therefore generate very low profits, or are even unprofitable, since the cost of serving them in about equal to or even exceed their revenues (Shapiro *et al*., 1987). The segment at th bottom of the pyramid is often relatively large in number of customers, but generates very little or no profit due to inactive purchasing behaviours (Blömeke *et al*., 2010). The internal banking survey from the Chartered Institute of Banking by 1999 reveals that 56% of senior bankers are looking at methods of getting rid of unprofitable customers. The purpose of this paper is intended to extend the understanding of the relationship termination phase in the consumer banking sector, especial with these relationships are not required on a continuous basis or one they have served their function.

LITERATURE REVIEW

Relationship Marketing

Every marketplace exchange transaction involves a relationship. Some transactions are never repeated, so a relationship between a buyer and a seller could be momentary (Reddy and Czepiel, 1999). However, relationship marketing should be concerned with the nature of long-term relationship between business and customer which takes into account customer needs and values. Interest in the nature of relationship marketing has increased in B2B marketing as well as B2C marketing literature over the last three decades. Relationship marketing, according to Berry (1983), means attracting, maintaining and strengthening the relationship a company has with a customer in order to retain that customer. This definition became the foundation upon which most subsequent definitions built. For example, Christopher *et al.* (1991) define the function of relationship marketing as 'getting and

keeping customers'. Morgan and Hunt (1994) add the importance of trust, cooperation and shared values in order to maintain a successful relationship. Grönroos (2000, pg.39) defines relationship marketing as "*to identify and establish, maintain and enhance, and when necessary terminate relationships with customers (and other parties) so that the objectives regarding economic and other variables of all parties are met. This is achieved through a mutual exchange and fulfilment of promises*".

Moreover, it has been argued that the establishment and maintenance of any relationship will face the possibility of termination. For example, because of the cost involved, a company should not build a relationship with all of its customers. In fact, a few early academic papers have drawn attention to how considerable resources have sometimes been freed up and put to better use by dissolving unprofitable relationship (see for example, Storbacka *et al*., 1994; Blois, 1996). With this in mind, Moriarty *et al*. (1983) suggest the concept of relationship banking is based upon an acceptance that the bank can increase its earning by maximising the profitability of the total number of customer relationships over time, instead of seeking to acquire the most profit from any single product or transaction. In other words, the objective of relationship marketing is to create results in the long run through enduring and profitable relationships with customer; however, such relationships are usually, but not necessarily always long-term.

Relationship Termination

Relationship research has, however, indicated that termination may occur in any of the phases of a relationship's development (Halinen, 1997). It has become clear that dissatisfied customers may also exit the relationship (Ganesh *et al*., 2000; Halinen and Tähtinen, 2002). Thus, research indicates that insight into the nurturing of closer relationships does not guarantee the understanding of the termination process (Keaveney, 1995). Halinen and Tähtinen (2002, pg.166) characterise the relationship termination as a process where these links, ties and bonds are broken, disconnecting the former parties from each other. Hence, it is particularly important for the bank because the termination is likely to influence other connected customers and relationships and create changes in the relationship network (Anderson *et al.*, 1994; Halinen and Tähtinen, 1999).

In this paper, this study reviews and assesses previous studies concerning the ending of exchange relationships. According to Halinen and Tähtinen, (2002), relationship termination could be interpreted as a process where links, ties, and bonds (e.g. exchange of objects, personal relationships, contracts, bonds of trust and commitment) are disconnected. Although some authors may use different terms such as 'relationship break-up',

'disengagement', 'withdrawal', 'ending' or 'dissolution' (Tähtinen, 2001; Havila and Wilkinson, 2002) to explain the relationship termination, all these terms present the same meaning of termination which is understood as a situation where '*at least one partner no longer views the relationship as continuing or the interdependency has otherwise critically decreased*' (Tähtinen, 2001, pg.46).

Relationship Termination in Banking Sector

Not all customers want to engage in relationships and, in fact, it has been suggested that close customer relationships in banking are rare, and that relationships are being further weakened by the increases in self-service technologies (O'Loughlin *et al.*, 2004). The type of the relationship may also have important effects on its termination. For example, banks may promote one financial product or service with a particular purpose and/or time period, which then gives the client a natural break-out point straight after the project, has been accomplished. These services are not required on a continuous basis or once they have served their function (see for example, Dwyer *et al*., 1987; Hocutt, 1998). However, although the formal communication between the entities involved may no longer continue, personal bonds may be maintained between individuals from both companies (Havila, 1996; Tähtinen and Halinen-Kaila, 1997). For example, a bank may keep the former customer's name in its reference list if the ex-customer agrees to this arrangement (Tähtinen and Halinen-Kaila, 2000). Alajoutisjarvi *et al.* (2000) proposed this action as "beautiful exits" avoiding the future, potentially damaging effect when dissolving a relationship.

Termination is seen as a managerial activity as part of relationship management (see for example, Reinartz *et al*., 2004). Grönroos (1994) agrees that the objective of relationship marketing is to create results in the long run through enduring and profitable relationships with customers; however, such relationships are usually, but not necessarily always long-term. Therefore, applying this definition provides a good starting point for understanding business relationship terminations in general. However, relationship termination here does not mean that firms terminate all unprofitable relationship regardless of their potentials for development. It is merely accepting termination as one option in managing its relationships.

DATA COLLECTION AND ANALYSIS

Data collection took place between August 2007 and April 2008. Within Taiwan there are 41 consumer banks (Financial Supervisory Commission, 2006). All 41 banks were contacted by phone and email and asked to participate in the research. 17 banks agreed to take part and 34 in-depth interviews were conducted. All managers interviewed claimed to have

knowledge of their relationship marketing and relationship termination strategy, and typically occupied posts such as Marketing Manager or Vice President Personal Banking Division. An interview guide was used during the interviews which included questions asking what the interviewee understood by the term 'relationship termination', what circumstances bank will terminate to determine dissolution the relationship with customers? All interviews were taped, transcribed and analysed using thematic coding.

FINDINGS

Not Actively Terminating the Customer Relationships

Although Taiwanese banks are willing to terminate the relationship with unprofitable customers, all respondents from this study strongly indicated that they were not allowed to apply such a decision. Perhaps, bank employees still have certain constraints preventing them from exercising their initiative to terminate unprofitable relationships. This study classified all the descriptions into two possible reasons. First, The Taiwanese government policy limits the equity of the relationship termination in which the termination only occurs in certain conditions e.g. dormant accounts (i.e., no account activity for at least a year) or a bad debt (e.g. an uncollectible account or irrecoverable loans or credits). In other words, except for customers that have been proven to have committed illegal economic activities or bad debt (e.g. an uncollectible account or irrecoverable loans or credits), banks could not terminate the relationship with their customers actively. For example,

> "*We won't terminate the relationship actively because we are a service industry…our law or policy does not allow it to happen either*".

Second, considering the reputation and integrity, so the bank would not take steps to terminate the relationship. For example, one interviewee claimed,

> "*Banks should consider customers' feelings, so it is not appropriate for banks to terminate the relationship without common agreement*".

Therefore, banks particularly concerned about negative word-of-mouth advertising as a result of terminating relationships with unprofitable customers, so they will not actively terminate the customer relationships.

Maintaining Relationships and Changing Service Forms

The majority of respondents described their willingness to dissolve unprofitable customer relationships, but knew that this was not permissible. Thus, banks manage the discrepancies by putting these 'problem' customers on the touch-tone (e.g. ATM, Internet banking) or voice-mail support (e.g. telephone banking, call centres) to reduce the time and costs associated in engaging with such customers.

But do all customers be willingness to accept using technology? Not necessarily, as some customers, particularly elders still prefer face-to-face contact with banks. For example, one interview described that,

> "*72% of bank consumers, particularly older people...enjoy the social interaction of visiting a local bank branch, especially if they know the staff members who serve them and don't trust machines*".

Bank managers also believed that more time may be required to encourage customers to accept these kinds of self-service options.

***Guanxi* and Relationship Termination Decision**

Considering highly competitive consumer banking marketplace, especially, where competition is as high as it has ever been, where the customer base is saturated with offers from every other bank. Bank mangers strongly asserted that if it was possible, they were more likely to maintain *guanxi* (personal relationship) with former customers. This study also finds that sometimes a financial advisor or account manager may transfer to another bank, where a few of his/her customers may follow of *guanxi*:

> "*Customer relies on the trust of their financial advisor they know, rather than the bank. Every service staff member has his own Guanxi network which might contribute to us, but if he leaves, he may take the Guanxi with him and the bank loses business*"

G*uanxi* is an important cultural and social element in Chinese society. This Chinese term first appeared in the West in the 1980s to offer advice about cultural factors impacting on business relationships in China (Alston, 1989; Fan, 2002). The finding confirms and demonstrates this cultural influence on business operations in Taiwanese consumer banking sector. Banks may decide not completely terminated customer relationships but possibly continued to maintain *guanxi* with former customers, especially when some *guanxi*

relationships are too complicated to be ended abruptly. Interestingly, this result differ to those of Morgan and Hunt (1994), who argue that relationship marketing typically impersonal and mostly occurs at the organisational level. In other words, *guanxi* works at personal level and further extends to business performance.

DISCUSSION

This research discovers an interesting result that Taiwanese banks declined to terminate relationship although not all customer relationships are profitable and willing to engage in long-term. Different than Western studies (see for example, Grönroos, 2000; O'Loughlin *et al*., 2004; Helm *et al*., 2006), Taiwanese banks consider relationship termination with customers might have influence on their reputation, so banks would still hold the relationships but encourage these less profitable customers to use self-control services (i.e. ATM) in order to save cost and time. In addition, it is clear that it is necessary to consider the personal relationship (*guanxi)* as a feature of business performance in East.

Some authors (e.g. Grönroos, 2000; Tähtinen, 2001; Giller and Matear, 2001) indicate that ending the unprofitable relationship should be considered in order to reduce the operation costs and focus on the valued customers. However, this study suggests that although banks had recognised and agreed with this aspect, they are still more likely to continue these customer relationships. This strategy is different to western theories although many studies in relationship marketing illustrate the potential benefits in terminating these non-profitable or less profitable relationships. This type of research only shows part of the overall picture. Relationships with customers are complicated and dynamic, not static. This is particularly true of Chinese culture, where *guanxi* places lots emphasis on the continuity of the relationship. This study also extends the findings of the existing literature and provides some explanations as to why relationship termination is unlikely to occur within Taiwanese banks. Although business relationships might have been decreased, *guanxi* could still be remained.

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HOUSEHOLDS ELECTRICITY MARKET IN SLOVENIA: LIBERALISATION AND IMPLICATIONS

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ABSTRACT

This paper analyzes households' electricity market in Slovenia. While the number of suppliers in the households electricity market has increased and the initially increased market competition resulted in the process of switching of the consumers between the suppliers, the electricity price developments after the initial short-period of decline and stability has increased. This has raised the question whether the household's electricity consumers overpaid the electricity and whether electricity suppliers have to return for overcharged and overpaid households' electricity bills due to an oligopoly agreement on market supply division and electricity price settings. We find that consumption of electrical energy by households is positively associated with real income of households, which is expressed by real wages, but negatively associated, with real price of electrical energy for households at the higher tariff. It is also positively associated with real prices of substitutes for natural gas for households or for fuel oil as well as with a dummy variable for market liberalization of electrical energy market for households.

Key words: market liberalisation, households demand, electricity market, Slovenia

INTRODUCTION

Energy markets in Europe have been gradually liberalised with an aim to encourage competition and to increase market efficiency. We focus on electricity market liberalisation for households in Slovenia and its implications for households' electricity bills, electricity suppliers, and society. The gradual deregulation and liberalisation of the electricity markets in Slovenia has been completed since mid-2007. The initial deregulation in Slovenia has started in 2001 with the liberalisation of the electricity market for the largest industrial users of electrical energy. The deregulation has followed in the mid-2004 for the other electricity users, except for households, and in the mid-2007 also for the households' electricity users (Bojnec and Papler, 2006a, 2006b, 2010; Papler and Bojnec, 2006, 2007; Pollitt, 2007). The entry of new competitive suppliers and free trade, particularly possible import comptition, might contribute to the increased quality and price competition.

While the number of suppliers in the households electricity market has increased and the initially increased market competition resulted in the process of switching of the consumers

between the suppliers, the electricity price developments after the initial short-period of decline and stability has increased. This has raised the question whether the household's electricity consumers overpaid the electricity and whether electricity suppliers have to return for overcharged and overpaid households' electricity bills due to an oligopoly agreement on market supply division and electricity price settings. To test these hypotheses, we employ different empirical approaches. First, we present summary statistics on main households' electricity market developments in supply, demand, and real price developments. The market structure is measured by Lorenz curve and by Gini coefficient of market concentration. Second, we present issues of cartel agreement between suppliers and its implications due to overpaid electricity for consumers in the case of the typical standard consumer group during a controversial period of the overcharged electricity bills for households. On this basis we present welfare implications of the electricity market deregulation for a typical household in Slovenia on its electricity bill, implications for electricity suppliers, and for society. Third, we employ regression analysis (e.g. Kachigan, 1991; Norušis, 2002) to test the association between the household's electricity consumption and real price of electrical energy, real income and real prices of substitutes for electrical energy. In the estimation of the demand function for electricity consumption by households we estimate the sign of association and significance of the association of electrical energy consumption with direct price, income and cross-price elasticity. We find that consumption of electrical energy by households is positively associated with real income of households, which is expressed by real wages, but negatively associated, with real price of electrical energy for households at the higher tariff. It is also positively associated with real prices of substitutes for natural gas for households or for fuel oil as well as with a dummy variable for market liberalization of electrical energy market for households. Finally, we derive managerial implications for electricity suppliers, welfare implications for households' electricity consumers and society, and policy implications.

MARKET SHARES AT THE LOCAL ELECTRICITY MARKETS

Households are according to technical conditions for electricity use classified into three tariff groups I (connection power 3 kW), II (7 kW), and III (10 kW). In addition, the distribution enterprises have introduced the fourth package that is offered for above standard users with 23 kW of the installed connection power (Papler, 2008). The second group is the largest by the number of electricity users. In 2008, the average monthly consumption of electrical energy per households was 331.1 kWh. Moreover, households users of electrical energy by the size of annual electricity used are grouped into the five size groups: up to 1,000 kWh, from 2,501 to 5,000 kWh, from 5,001 to 10,000 kWh, from 10,001 to 15,000 kWh and above 15,000 kWh. The increases are for the largest users and decreases for the smaller users. The electricity consumption by households represents about one-third of the electricity consumption in Slovenia.

Since the electricity market liberalization, the new suppliers have entered into the markets. This has been reflected in the deterioration of the local regional supplier's market share, which have been taken by others non-local regional suppliers. Prior to the electricity market liberalization for households, they were dependent on the supply from one of the five regional distribution

enterprises in Slovenia. Electro Ljubljana had around one-third market share, Electro Maribor almost one-fourth, Electro Celje less than 18%, Electro Primorska around 14% and Electro Gorenjska a bit more than one-tenth market share. Since the market liberalization, into the electricity market for households has entered GEN-I and some other smaller suppliers, this has resulted in some changes in market shares, but they have not changed substantially (Ministry of Economy, 2009).

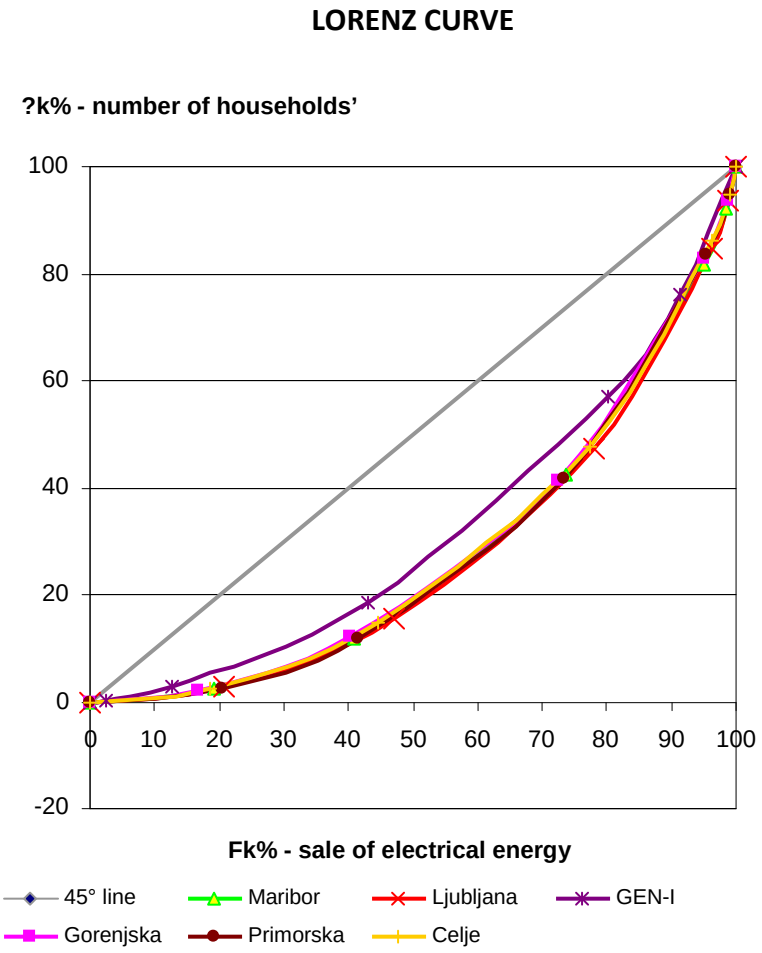
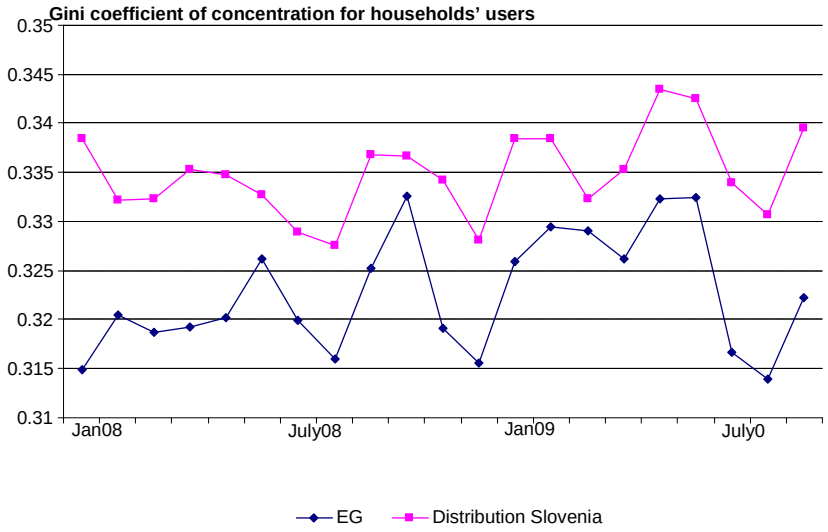


Figure 1: Lorenz curve for concentration of households users of electrical energy by suppliers in Slovenia, January – June 2009.

Among the most often used measures for presentation of distribution of appearance differences are Lorenz curve and Gini coefficient of concentration. We use these measures to present distribution of relative frequency in the sale of electrical energy. Figure 1 presents the relative frequency distribution in sale of electrical energy for households' users by the five electricity distribution enterprises and for the GEN-I. The concentration of Slovenian households' users is modest and rather stable over time. For example, for Electro Primorska and Electro Gorenjska around 40% of households' users spent around 72% of electricity or 83% of households' users spent 95% of electricity, which these to enterprises supplied to the

households' users. In the case of Electro Maribor is similar: 42% of households' users spent around 74% or 82% of households' users spent 95% of electricity, which is supplied to the households' users. Electro Celje and Electro Ljubljana sold to 48% of households' users 78% of electricity or 86% of households' users bought 96% of electrical energy, which these two enterprises sold to households' users. The new supplier GEN-I has more equal distribution of households' users.

GINI COEFFICIENT OF MARKET CONCENTRATION



EG – Electro Gorenjska.

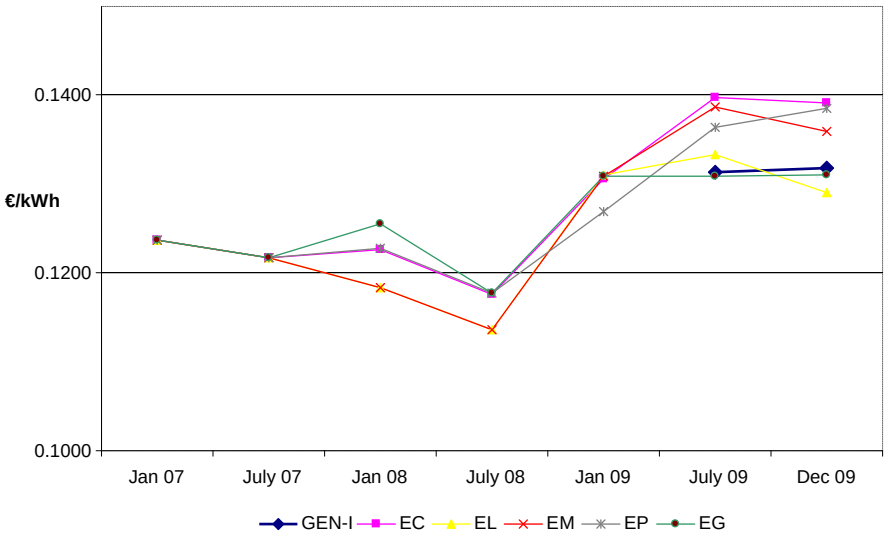
Figure 2: Gini coefficient of concentration of households' users for the EG and distribution enterprises in Slovenia, 2008–2009.

Figure 2 shows variations in the Gini coefficient of concentration of households' users by the electricity distribution enterprises and for the EG electricity supplier. This implies some changes in the suppliers market shares and market concentrations over time with the entry of the EG into the Slovenian households' electricity market.

PRICE DEVELOPMENTS

The retail price of electrical energy for households with the annual electricity consumption of 3,500 kWh (user group *Dc)* is the closest to the average Slovenian households by the electricity consumption. In March 2007 in Slovenia was introduced excise tax on electrical energy and prior to the electricity market liberalization for households in July 2007, the prices of electrical energy for households by the five distribution enterprises were uniform. However, since then there have started price differentiations with introduction of different packages and bonuses for households' consumers by the individual electricity suppliers, which is illustrated for the

average real price for the user group *Dc* for energy, for network grid, contributions, excise tax and value-added tax (Figure 3).



Note: EC – Electro Celje, EL – Electro Ljubljana, EM – Electro Maribor, EP – Electro Primorska and EG – Electro Gorenjska.

Figure 3: Real price of electrical energy for standard user group Dc for energy, network grid, contributions and taxes by different suppliers, 2007-2009.

OVERPAID ELECTRICITY BILLS BY HOUSEHOLDS IN THE CASE OF THE ELECTRO GORENJSKA

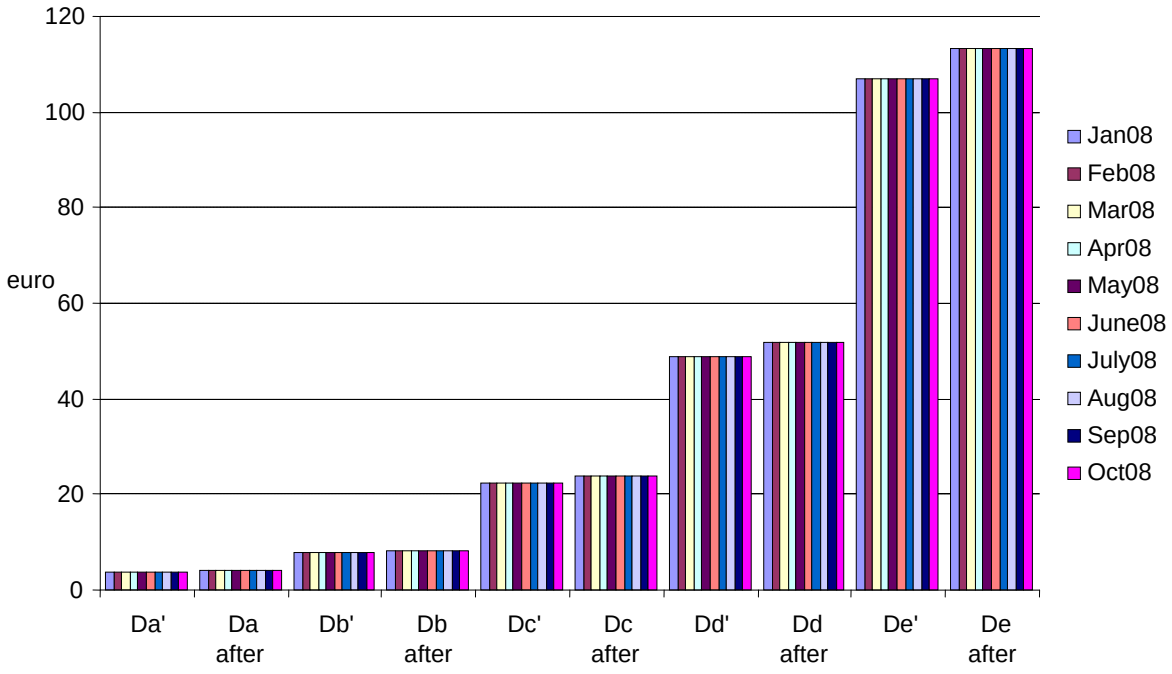
The subject of the return for the overpaid electricity bills by households in the case of the EG was the difference between the price of electrical energy from the start of price increase on 1st January 2008 up to the introduction of the new prices on 27th October 2008 jointly with the legal interest for delay from the date of an overdue invoice up to 30th September 2010. Due to a fact that the supplier did not disclosure evidence on the volume of electrical energy supply during this period, we calculate overpaid electricity bills by monthly amounts for typical standard households electricity consumers groups *Da, Db, Dc, Dd,* and *De*. According to the Eurostat (2011) standards, the standard households' electricity consumers groups consider the following criteria: *Da* – lights, radio and TV, fridge, small households' appearances (annual electricity consumption 600 kWh, power 3 kW; *Db* – as *Da*, but also washing or dish-washing machines (annual electricity consumption 1.200 kWh, power 3-4 kW); *Dc* – as Db, but also boiler (annual electricity consumption 3.500kWh, out of this 1.300 kWh during the night time; power 4-9 kW); *Dd* – as Dc (annual consumption 7.500 kWh, out of this 2.500 kWh during the night time, power 6-9 kW); *De* – as Dd, but also thermo accumulation electric stove (annual electricity consumption 20.000 kWh, out of this 15.000 kWh during the night time, power 9 kW). These characteristics of households' electricity consumption are considered in Table 1.

Table 1: Households' electricity consumption characteristics for standard consumption groups in Slovenia.

Symbol	Users group	Calculation power	Annual (monthly) consumption	Annual (monthly) consumption HT	Annual (monthly) consumption ST	Annual (monthly) consumption ET
		kW	kWh	kWh	kWh	kWh
Da	I degree – ET	3	600 (50)			600 (50)
Db	I degree – ET	3	1,200 (100)			1,200 (100)
Dc	II degree – 2T	7	3,500 (291.7)	2,200 (183)	1,300 (108)	
Dd	II degree – 2T	7	7,500 (625)	5,000 (417)	2,500 (208)	
De	III degree – 2T	10	20,000 (1,667)	5,000 (417)	15,000 (1,250)	

ET – one-tariff measuring, 2T – two-tariff measuring, HT – high tariff, and ST – small tariff.
Source: Ministry of Economy (2009).

The monthly bills for electrical energy consumption for standard consumer groups without value-added tax were the following: *Da* was 3.83 euro before the price increase, and 4.07 euro after cartel agreement; *Db* 7.66 euro and 8.14 euro; *Dc* 22.36 euro and 23.79 euro; *Dd* 48.83 euro and 51.96 euro; *De* 106.80 euro and 113.47 euro (Figure 4).



*After the cartel price increase
Figure 4: Monthly bill for households' electricity consumption for standard consumers groups prior and after the cartel price increase without value-added tax.

Table 2: Overpaid electricity bills by standard households electricity consumer groups without value-added tax.

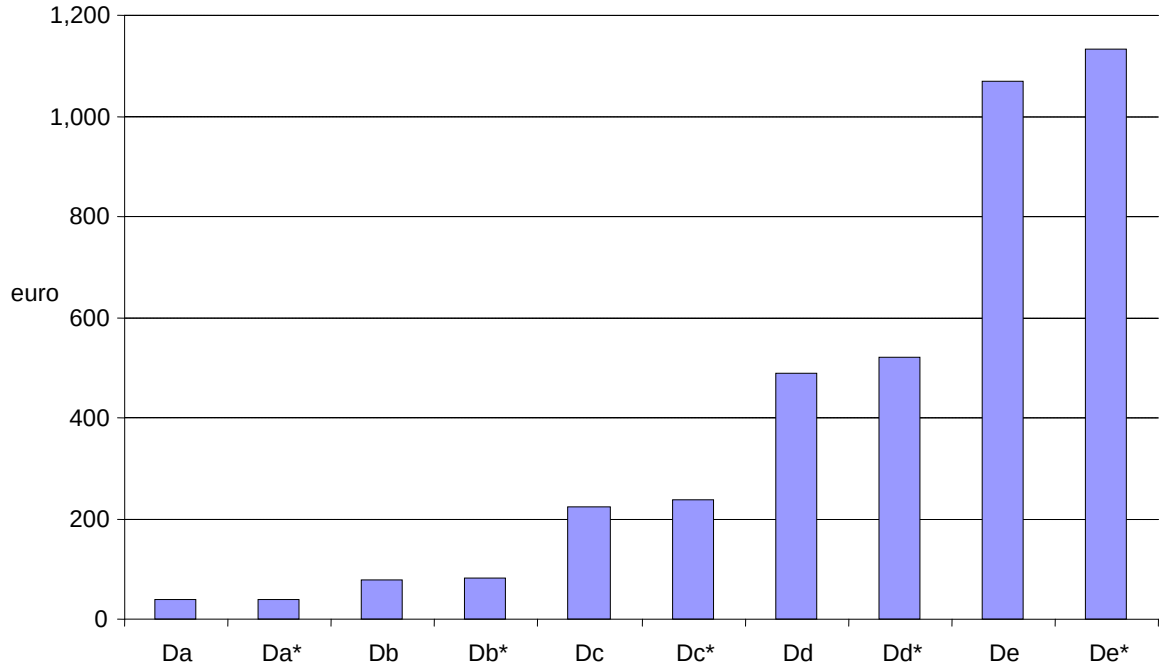
	Da		Db		Dc		Dd		De	
2008	euro	%	euro	%	euro	%	euro	%	euro	%
January	0.2440	6.0	0.4880	6.0	1.4312	6.0	3.1321	6.0	6.6669	5.9
February	0.2440	6.0	0.4880	6.0	1.4312	6.0	3.1321	6.0	6.6669	5.9
March	0.2440	6.0	0.4880	6.0	1.4312	6.0	3.1321	6.0	6.6669	5.9
April	0.2440	6.0	0.4880	6.0	1.4312	6.0	3.1321	6.0	6.6669	5.9
May	0.2385	5.9	0.4770	5.9	1.3992	5.9	3.0633	5.9	6.4835	5.7
June	0.2385	5.9	0.4770	5.9	1.3992	5.9	3.0633	5.9	6.4835	5.7
July	0.2385	5.9	0.4770	5.9	1.3992	5.9	3.0633	5.9	6.4835	5.7
August	0.2385	5.9	0.4770	5.9	1.3992	5.9	3.0633	5.9	6.4835	5.7
September	0.2385	5.9	0.4770	5.9	1.3992	5.9	3.0633	5.9	6.4835	5.7
October	0.2385	5.9	0.4770	5.9	1.3992	5.9	3.0633	5.9	6.4835	5.7
Cumulative	2.4070	5.9	4.8140	5.9	14.1197	5.9	30.9081	6.0	65.5686	5.8
% of monthly bill	59.1		59.1		59.4		59.5		57.8	

In January 2008, price of electrical energy in Slovenia increased on average by 6.0%. Between January and October 2008 the overpaid households' electricity bills by standard consumer groups without value-added tax were the following: *Da* 2.41 euro, *Db* 4.81 euro, *Dc* 14.12 euro, *Dd* 30.91 euro and *De* 65.57 euro (Table 2). The overpaid electricity bills in total households' monthly bills for electricity amount between 57.8% for De and 59.5% for Dd. The standard group Dc, which is the closest to the Slovenian household average, experienced the overpaid bills of 59.4% of monthly costs. The standard groups with the smallest electricity consumption Da and Db experienced the overpaid bills of 59.1% of monthly costs.

With the value-add tax, the overpaid households' electricity bills by standard consumer groups were the following: *Da* 2.89 euro, *Db* 5.78 euro, *Dc* 16.94 euro, *Dd* 37.09 euro and *De* 78.68 euro (Table 3 and Figure 5).

Table 3: Overpaid electricity bills by standard households electricity consumer groups without value-added tax, January – October 2008 (in euro).

	Da	Db	Dc	Dd	De
2007 price	38.28	76.55	223.59	488.32	1,068.03
2008 price increase	40.68	81.36	237.71	519.23	1,133.60
Overpaid electricity January – October 2008	2.41	4.81	14.12	30.91	65.57



*with overpaid electricity

Figure 5. Electricity bills by standard households' consumer groups with value-added tax, January-October 2008

REGRESSION ANALYSIS FOR CONSUMPTION FUNCTION OF HOUSEHOLDS' ELECTRICAL ENERGY CONSUMPTION

The quantity of consumption of electrical energy by households (D_h) is explained by real households' income or net wage (Wage) or real households' expenditures for electricity, gas and water (E_h) and real price of electrical energy for households at the higher tariff rate (P_{h_HT}). Table 4 in the case of the EG indicates that the electricity consumption by households is positively associated with the real households' income variables and negatively associated with the real electricity prices.

Table 4: Consumption function of electrical energy in households on the higher tariff rate.

	ln(constant)	$\ln(H_h)$	ln(Wage)	$\ln(P_{h_HT})$	$AdjR^2$	F
$\ln(D_h)$	-3.764	0.288		-1.215	0.995	1,125.0
	(-8.713)	(2.659)		(24.97)		
$\ln(D_h)$	3.119		0.299	-1.219	0.996	1,155.4
	(-16.568)		(2.739)	(-25.008)		

ln – natural logarithm. t-statistic in the brackets.

Moreover, we estimate consumption function of electrical energy by households for the EG, which is additionally explained with real prices of substitutes and the changing market share variable and the Gini coefficient of concentration of households' users. Table 5 confirms that household's electricity consumption for the standard price group is negatively associated with the real electricity price, but positively associated with the real price of substitute, real wage and the Gini coefficient of concentration, but the regression coefficients, which are pertained to the latter three variables, are not significant.

Table 5: Consumption function of electrical energy in households for the standard price group.

	ln(constant)	ln(Psga)	ln(Psgb)	ln(Poil)	ln(Wage)	ln(Gini)	AdjR^2	F
ln(D_h)	16.978		-0.556	0.042	0.167	0.081	0.233	2.5
	(6.802)		(-2.422)	(1.106)	(0.499)	(0.211)		
ln(D_h)	16.610	-0.548		0.041	0.163	0.082	0.229	2.5
	(6.765)	(-2.401)		(1.086)	(0.486)	(0.214)		

ln – natural logarithm. t-statistic in the brackets.
Note: *Psg* – real price of electricity for standard households' group *a* and *b* and Poil – real price of fuel oil.

CONCLUSION

The electricity markets in Slovenia have been liberalized to become more competitive in the future. Electricity markets for households are still highly concentrated. The real incomes have played important role in demands by households, but significant role has played the price of electrical energy for households. The households are sensitive on the suppliers' price developments, which has so far encouraged a successful entry into the households' electricity market and an increase of the market share of the new GEN-I supplier with a favorable price and quality of supply.

The issues of cartel agreement between suppliers and its implications due to overpaid electricity for consumers in the case of the typical standard consumer group during a controversial period of the overcharged electricity bills for households are analysed. The overpaid electricity bills by households increased their costs of living, but with the return of the overpaid electricity bills they can potentially gains not only with this temporary return, but also with a greater transparency of electricity price formation in future, which is important for households and society welfare implications from the electricity market deregulation. At the same time this is also a clear signal for the electricity market participants, namely electricity suppliers and households consumers as well as institutions responsible for implementation of transparency of market competition that formal market liberalisation is not enough that free market forces can start to work in a perfect way as there might be persistence of formal and informal institutions and networks, which might reverse potential households and social welfare gains from electricity market deregulation and price liberalisation.

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ELEMENTS OF SPACE STYLE AND MUSIC STYLE ON THE HIGH AESTHETIC, EMOTIONAL, EXPERIENCE QUALITY AND EXPERIENCE SATISFACTION STUDY

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ABSTRACT

The democratization of style and taste, and common people, from a variety of print media continue to discuss the economic and life style issues related to aesthetics, the subtle feelings and emotions triggered by the aesthetic elements and experience show that the elements of future trends. In the past, foreign and domestic are popular types of jazz music, the rapid development in recent years, stunning, particularly in the LIVE BAND PUB ubiquitous today. This study documented the elements of space music elements, high-end aesthetic elements, emotional elements and experience quality literature presented from the customer's point of view to find space for style and aesthetics of music style for the consumer perception, emotion, and experience the quality of relevance. Hope that by understanding customer perceptions of the actual store experience, to store the continuing or improving future business direction.

The samples were selected merchants for the Blue Note and Riverside Blue's mansion shop 2 live jazz restaurant, paid a total of 450 questionnaires.

Through this research are known: Jazz aesthetic elements and space elements are on the experience of satisfaction has an indirect positive impact of business improvement can be used as a reference. The level of spatial information is causing a sense of musical elements of their experience with the correlation of the reasons for the change, a sense of spatial information to increase customer associate degree this space music. High aesthetic elements and experience the satisfaction of this study is proportional to the new argument, so how to make customers feel that the very existence of the store is believed to be the new challenges of the future services.

Keywords: High aesthetic elements, Aesthetic elements of space, Jazz, Experience quality

INTRODUCTION

Study Background

In recent years, Taiwan society has showed some changes; for example, the public all fancy cute stuffs, nightclubs are almost everywhere, and people all love Wang. Regardless of price, style has become the mainstream and charisma prevails (Liu Wei-gong, Associate Professor; Social Science Department of Soochow University). The democratization of style and taste promoted by a variety of media through persistent discussion over the economic and life style issues has triggered subtle feelings and emotions, which reveal the future trend of aesthetic and experience elements.

With the rise of experiential society, "charisma competitive advantage" has gained more and more attentions. Unlike previous competition models which compete with volume, price, working hour, salary, and capital, today's competition is more about taste, style, content, texture, and unique characteristic.

Taiwanese enterprises often wonder why other competitors' products have gains more attentions from consumers while their product functions are no worse than those of competitors' products. Taiwanese enterprises normally have to use promotion to see effect. Why Taiwan's products cannot easily grab market attention during new product launches just like those of Apple, Lexus, and Starbucks and other brands? We attribute this result to Taiwan enterprises' ignorance towards charisma competitive advantages, which has led to Taiwan's current inferior status in today's experiential society.

Jazz, which used to belong to alien and non-mainstream music in Taiwan, has shown stunning development in recent years with significant record sales growth and growing fans as more foreign jazz musicians perform in Taiwan. Nowadays, live band pubs are everywhere, providing more chance for nationals to experience jazz in person.
To experience economic time's beauty is not the exclusive privilege of aesthetics. Communication through senses towards people, location, and object's outlooks instead of words will arouse the reflective communication art.

Beauty should be presented naturally instead of being said; beauty can automatically make people feel joyful without directing; the effect of beauty is immediate, visual and emotional. Although we may analyze the effect of beauty afterwards but the effect shouldn't be learnt through recognition.

Study Objectives

This study has sorted out relevant documents regarding elements of space, music, high-end aesthetic, emotional, and quality of experience and brought the following study objectives.

1) Based on customer's perspective, we find the relevance between the space style and music style in jazz live-band pubs (atmosphere) and consumer' aesthetic perception, emotion and quality of experience.
2) Understand customer's satisfaction level towards all sorts of experiences in Jazz live-band pubs (aesthetics, emotion, quality of experience)
3) Hope to give stores future direction of sustainability and improvement through understanding customers' perception of experience in Jazz live-band pubs.

EMPIRICAL CONCLUSION AND MANAGERIAL IMPLICATIONS

1) The relationship between the aesthetic elements of space (transparency and information sense) and high-end aesthetics
Transparency and information sense all positively contribute to high-end aesthetics. Information sense has bigger impact than transparency sense.
We suggest stores with live performance to smartly utilize interior design to increase transparency and visibility and cleverly design a theme to offset the crowded sense caused by the limited space in current modern unban society and to increase customers' appraisal towards such stores.

2) The relationship between Jazz music elements (improvisation, innovation, and localization) and high-end aesthetics.
Improvisation and localization have positive impact on high-end aesthetics while innovation doesn't have. Among the variables, localization has a bigger impact than improvisation.
We suggest stores with jazz performance can incorporate local elements into their music styles. For instance, it will help enhance store's quality by adopting domestic pop music. The most important element of jazz music is improvisation, but we believe more local elements will help show the store' irreplaceable uniqueness.

3) The relationship between space aesthetic elements (transparency sense and information sense) and emotion. Information sense has positive impact on emotion while transparency doesn't. We suggest night clubs with rock music performance should adopt interior design of Brooklyn graffiti or hang photos of rock stars such as the Beatles to resonate with customers. The most important thing for store with live performance is to arouse audience's emotions to make them feel high and relaxing, therefore it will not help the atmosphere on the spot without a matching interior design style and theme.

4) The relationship between Jazz music elements (improvisation, innovation, and localization) and emotion
Improvisation and localization have positive impact on emotion while innovation does not. Meanwhile, improvisation has a bigger impact than localization.
We suggest stores with Jazz music performance to increase special sessions of improvisation because Jazz music is so charming, relaxing, and renowned for its element of improvisation. Audiences always applauded performers' improvisation on spot with vibrant but relaxing emotions.

We also suggest Jazz music performers add some local elements; for example, they can link music with the life stores of local performers, which will help echo with audience' emotion.

5) The relationship between Aesthetic elements of space (transparency sense and information sense) and the quality of experience'

Information sense has a positive impact on quality of experience while transparency sense does not. We suggest stores design with layout that matches the store's theme. If customers are surprised and feel a sense of suspension, the information sense of the store's space is matching with its style, which will increase customers' learning inclination and participation.

6) The relationship between Jazz music elements (improvisation, innovation, and localization) and the quality of experience'

Improvisation, innovation and localization have positive impact on quality of experience with variable intensity: innovation> Improvisation> localization.

We suggest store with jazz music performance have certain degree of requirement for performance innovation because the higher innovation degree in Jazz music will easily arouse audience's surprise and learning along with their participation and immersion. Improvisation is one kind of innovation to Jazz music; hence it also has an impact on quality of experience.

7) The relationship between high-end aesthetics, emotion, experience, and experience satisfaction.

High-end aesthetic, emotion, and quality of experience have positive impact on experience satisfaction with the variables intensity as: emotion> quality of experience > high-end aesthetic.

We suggest restaurants with jazz music performance emphasize on high-end r aesthetic, emotion, and all sorts of quality of experience, among which emotion has the highest impact on experience satisfaction because as customers' satisfaction won't reach certain level without pleasant consumption. Therefore, the most important thing is to make customers feel it's worthy of spending.

8) The relationship between space aesthetic element and Jazz music element of different music styles and high-end aesthetic, emotion, quality of experience, and experience of satisfaction.

To let customers experience the best effect of the in-store music performance, the store's decor and layout have to be related to the music, otherwise the performances will be hindered by mismatching information sense. Meanwhile we suggest music performers make the audience feel more involved.

We suggest the Riverside to focus on store décor and layout and to create some reference to jazz style; for example more three-dimensional decoration instead of simply some drawings and photos.

We suggest Blue Note focus on customers' emotions; for example, it should require music performers to have more interaction with customers and to converse with them instead of focusing on their performance.

CONCLUSIONS

This study shows empirical evidence that space aesthetic elements (transparency sense and information sense) and Jazz music elements (improvisation, innovation, and localization) all have direct positive impact on experience satisfaction, therefore can be used as a reference for business improvement.

This study found new evidence that high-end aesthetic elements (uniqueness, persistency, organic) have a positive impact on experience satisfaction. Therefore, the new future challenge for service industry is to make customers believe the store has an existing value.

Study contribution

1) Academic contribution

This study defines transparency sense and information sense of space aesthetic through literature review. Jazz music elements include innovation, improvisation, and localization while high-end aesthetic elements include uniqueness, persistency, and organic concept. Our analyzed result also points to that our measuring indicators have credibility and effectiveness.

Based on literature review, this study discusses the transparency sense and information sense of space aesthetic elements. We use innovation, improvisation and localization of Jazz elements as the dependent variables and, high-end aesthetic, emotion, and quality of experience as intermediate variables, and experience satisfaction degree as the dependent variable to address their correlation. We found most assumptions are valid.
This study will use the different music styles of our investigated two stores as disturbing variables to conduct comparison analysis. We find the space's information sense can increase customers' imagination towards music space. Our empirical results can offer definition and measuring basis for reference to following consumer experience studies.

2) Practical contribution

The study's empirical results can be applied to related industry fields, including all performance services, music related services, catering services and store services.
Despite the real world's application might not as simple as this study presents, we believe our empirical evidence can be used as important reference for industry practice.

PREDICTING CONSUMER INTENTIONS TO PURCHASE GREEN CARS: AN EMPIRICAL TEST OF COMPETING THEORIES

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ABSTRACT

The aim of this research is to find the key factors that would influence customer purchasing intentions for green cars. There is an increasing awareness that many of environmental problems are caused by human economic activities. For this reason, it is important to find and use a suitable model. "Theory of Planning Behavior (TPB)" was proposed by Ajzen in 1985 and is a famous and popular model to measure customers purchasing behavior intentions. Therefore, the researcher combined with other related aspects for the questionnaires. The rest of the research is organized as follows: The researches explore the TPB model and other related aspects by literatures in Section 2. Analyzing the past researches give us better picture on the behavior of the customer toward green cars. In the subsequent sections of the paper, the researcher focuses the expansion of research model. In Section 3 the existing approaches and relate to suitable aspects with TPB model would be discuss. The hypothesized models will be empirically test using the structural equation modeling (SEM) approach, supported by LISREL 8.8 software with maximum likelihood estimation.

Key words: Theory of Planning Behavior, Green Cars, Structure Equation Modeling

INTRODUCTION

There is an increasing awareness that many of environmental problems are caused by human economic activities. The activities not only consume huge amounts of resources, but also lead to the disposal of tons of pollutants into the environment at levels which nature can no longer absorb. This situation generates problems such as climate change, global warming, pollution, loss of biodiversity, and many more. Because of high-prices energy and conscious of environmental protection, green cars play an important role in cars purchasing. In the past research, many scholars focused designs of engines, fuel systems, and etc. The researchers always try to find out the way to decrease pollution. There are few research describing customer behaviors and purchasing needs of green cars. Thus, to find the key factors which would influence green cars buying intention is important.

There are some research pointed out that the primary task is to explore the needs of the customers and apply these needs in the development of green products (Baumann et al., 2002; Hart, 1995). These researches described that the designers have to consider what customers like and need, and put them together with production of green products. Many influencing factors such as characters of green products, customers satisfy, and customer relationship, were discussed in different research models. In this paper, the researcher tries to find out the purchasing intention of green cars. Turrentine (2001), Marcus (2009) and Ishioka (2009) sited that green cars are important in the green product industry.

The aim of this research is to find the key factors that would influence customer purchasing intentions for green cars. Base from the report, vehicle emissions contribute to the increasing concentration of gases linked to climate change (World Energy Council, 2009). In order of significance, the principal greenhouse gases associated with road transport are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O)(Marianne 2010). Road transport is the third largest source of greenhouse gases emitted in the UK, and accounts for over 20% of total emissions, and 33% in the United States. Of the total greenhouse gas emissions from transport, over 85% are due to CO_2 emissions from road vehicles. The transport sector is the fastest growing source of greenhouse gases (IPCC, 2007).

In order to reduce the greenhouse effect, for this reason, it is important to find and use a suitable model. “Theory of Planning Behavior (TPB)” was proposed by Ajzen in 1985 and is a famous and popular model to measure customers purchasing behavior intentions. Therefore, this research used TPB model to be a basis combined with other related aspects for questionnaires. The rest of the paper is organized as follows. TPB model and other related aspects by literatures is discuss in Section 2. Resorting to collect past researches could let the research model more complete. The development of green cars is discuss within this section. In the subsequent sections of the paper, we focus on the expansion of research model. In Section 3 we briefly discuss existing approaches and relate to suitable aspects with TPB model. The data collected by questionnaires will be analyze by the next research. The analysis method includes Principle Component Analysis (PCA), Analysis of Reliability and Validity, Regression Analysis, and One-way Analysis of Variance (ANOVA). By these results, we could know about the relationships among aspects and the key influencing factors for customers green cars purchasing behavior. The conclusions of this paper would be discussed of the implications of the use of the proposed research model to the manufacturing industry in the final section.

LITERATURE REVIEW

This research discusses the development and the consumer behavior toward green cars. Afterward, the development history of TPB model would be introduced by many researches. In the end of this section, we combined some related research with TPB model to built own research model for this study.

Green cars

A green cars or environmentally friendly vehicle is a road motor vehicle that produces less harmful impacts to the environment than comparable conventional internal combustion engine vehicles running on gasoline or diesel, or one that uses alternative fuels (RIC, 2005). Green cars are powered by alternative fuels and advanced vehicle technologies and include hybrid electric vehicles, plug-in hybrid electric vehicles, battery electric vehicles, compressed-air vehicles, hydrogen and fuel-cell vehicles, neat ethanol vehicles, flexible-fuel vehicles, natural gas vehicles, clean diesel vehicles, and some sources also include vehicles using blends of biodiesel and ethanol fuel or gasohol(US department of energy, 2010). Several author also include conventional motor vehicles with high fuel economy, as they consider that increasing fuel economy is the most cost-effective way to improve energy efficiency and reduce carbon emissions in the transport sector in the short run. As part of their contribution to sustainable transport, environmentally friendly vehicles reduce air pollution and greenhouse gas emissions, and contribute to energy independence by reducing oil imports (Green Student, 2010).

There are some attempts in the literature to define a green product (Elkington et al., 1988; Schmidheiny, 1992). Some studies focus on designing and marketing green products (Green et al., 1994; Roy, 1999; Vaughan et al., 1993). But it still confuses on what constitutes an environmentally friendly product, for consumers as well as for companies (Welford, 1998). Thought and needs form customers and companies are not the same, even they could be opposite to each other in some particular situations. Take fuel for example, customers always want characteristics of fuel include cheap and helpful to engine works. But some cheap fuel causes lots of pollution such as air pollution, and there is a duty for each company to maintain environmental protection. Thus, it is hard to get the balance between customers' needs and company's duty.

Fortunately, hybrid cars, solar-power cars, and other environmental protection vehicles have been invented in recent years. Not only cars' properties could be fit for environmental protection laws and terms, but also puts marketing essential factors like fashion into the car

design.

Many past researches focus on designs of engine and fuel systems. There are few researches to try to find the relationships between customers' needs and characters of green cars. Chang (2010) proposed a framework named "SEEDS" to describe the relationships amount "Supply Side", "Environment Protection Side", "Economic Side", "Demand Side", and "Substitute Side". Based on this framework, the author proposed some suggestions for different industries. Lantos et al. (2009) examined the felt need for new products in organizations, the usefulness of the new product development education, and the nature of the new product development discipline, for showing the paper's analysis of the death of the new product development courses in AACSB-accredited schools.

As the environment continues to worsen, the consumer has begun to realize the seriousness of the problem. Base on the needs of the consumer, businesses should design a green products to match the customers' demands. This paper could be seen as a pioneer in the research of green car design and customer behavior intention.

The theory of planning behaviors (TPB) model

The Theory of Planned Behavior was developed in response to a related existing model—The Theory of Reasoned Action (TRA) (Ajzen, 1988, 1991). Briefly, the Theory of Reasoned Action (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980) places intention as the principal predictor of behavior. So conceived, the more one intends to engage in behavior, the more likely is the occurrence of the behavior. Determining intention are attitude and subjective norm. The attitudinal determinant of intention is defined as the overall evaluation of behavior. This overall evaluation, in turn, is composed of the salient beliefs: the perceived likelihood of particular consequences of the behavior occurring, weighted by an evaluation of the consequences. The subjective norm determinant of attitude is conceptualized as social pressure from significant others to perform or not perform the behavior. The subjective norm, in turn, is composed of normative beliefs: the perceived pressure from salient referents, weighted by the motivation to comply with the referents. The TRA has received support across a range of contexts (Sheppard, Hartwick, & Warshaw, 1988). A recognized limitation of the TRA is that it was developed to deal with behaviors that are completely under an individual's volitional control (Ajzen, 1988; Fishbein, 1993). Figure 1 is the structure of TRA.

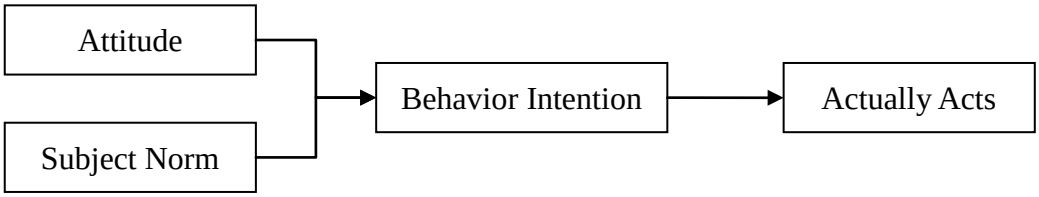

Figure 1: The structure of TRA.

In response to the aforementioned limitation of the TRA, Ajzen (1988, 1991) proposed an extension—the Theory of Planned Behavior. The TPB was designed to address behaviors not completely under volitional control. The model is identical to the TRA except that a perceived behavioral control construct has been added. Perceived behavioral control relates to the ease or difficulty of performing a behavior. Perceived behavioral control is affected by perceptions of access to necessary skills, resources and opportunities to perform a behavior, weighted by the perceived valence of each factor to facilitate or inhibit the behavior. In the TPB, perceived behavioral control is viewed as determining intention as well as behavior directly. The TPB has received strong support in predicting a wide range of intentions and behaviors (Godin and Kok, 1996; Sutton, 1998).

To understand the relationship between belief structures and antecedents of intention, several studies have examined approaches to decomposing attitudinal beliefs (Taylor and Todd, 1995; Chau and Hu, 2002; Chen et al., Jonathan, 2007; Riemenschneider et al.). Moreover, Shimp and Kavas (1984) suggested tha tthe cognitive components of belief would not be organized into a single conceptual or cognitive unit. According to Taylor and Todd (1995), in the TPB model, attitudinal, normative and control beliefs are decomposed into multidimensional belief constructs. The TPB model specified that, based on the diffusion of innovation theory (Jonathan, 2007), the attitudinal belief has three innovation characteristics that influence behavioral intentions are relative advantage, complexity and compatibility. Green technology can be considered a service innovation (Verhoef and Langerak, 2001). This study thus hypothesizes that the TPB model provides a more satisfactory explanation of behavioral intentions to purchase green cars..

The TPB (Ajzen, 1988 and 1991) extends the TRA (Fishbein, 1993), to account for conditions where individuals do not have complete control over their behavior. The TPB postulates that actual acts is determined by behavioral intention and perceived behavioral control. Behavioral intention is determined by three factors: attitude, subjective norms and perceived behavioral control. Each factor is in turn generated by a number of beliefs and evaluations.

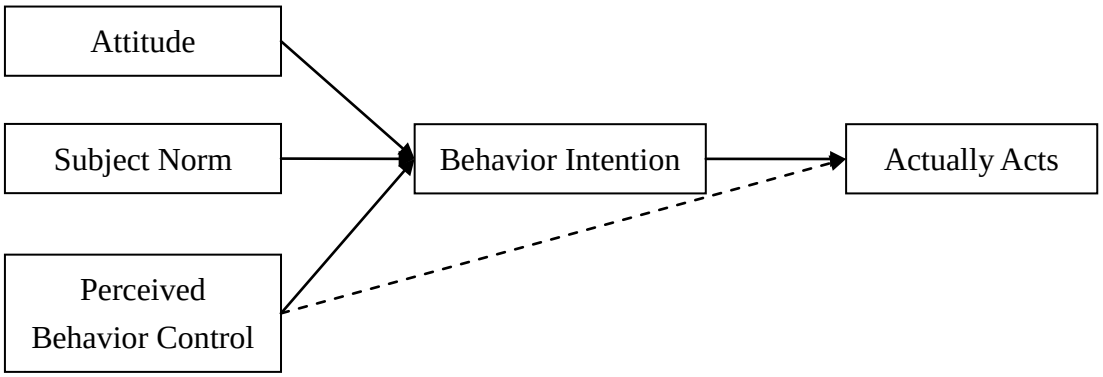

Figure 2: The structure of TPB.

"Behavior Intention" means personal volition and the volition would influence customers final decisions. Behavior Intention is impacted by two factors. One is an internal factor named "Attitude", and the other one is an external factor named "Subject Norm". "Attitude" is combined "Salient Beliefs (or Behavioral Beliefs)" with "Outcome Evaluation", and it means the feelings of customers when they try to do the specific thing. It could be good and bad, advantage and disadvantage, interesting and boring, or else (Ajzen, 1985). "Subject Norm" is combined "Normative Belief" with "Motivation to Comply", and it means people are under the pressure what they try to do something. The pressure is created by the people's parents, spouses, children, relatives, religious belief and etc. These individual suggestions would influence the behavior intention.

"Perceived Behavior Control" is combined "Control Belief" with "Perceived Facilitation", and it means when people try to do something, they would estimate how many the resources and opportunities they have and what kind of predicaments they might face to. "Perceived Behavior Control" could influence directly "Actually Acts" in some research, and some research shows the relationship between these two aspects is in-directly.

There is no past research using TPB model to measure green cars purchasing behavior intention. Thus, this paper could be the first research to estimate key influencing factors for behavior intention by using TPB model. With results of this paper, researchers could get valuable information from relationships among aspects.

THE RESEARCH STRUCTURE

In this section, we proposed a complete model for measuring influencing factors and green car purchasing behavior intention. We find and collect related research to create the structure. Based on past research, hypotheses would be proposed in objectivity. Some research results presented "Knowledge" would influence personal attitudes (Butler et al.,

1998; Hungerford et al., 1990; Limayem et al., 2000; Yan et al., 1999). People have different attitudes when they face to the same challenge because no one gets the same history of growing up and schooling. By these differences, people use own attitude to design what they like or what they want. Because of this, the hypothesis 1 is proposed as follow:

H1: Knowledge will have a significant impact on Attitude.

Clawson and Knetsch (1969) proposed product characteristics were the key factor that would influence customers' ability of perceived behavior control. Product characteristics include complexity, risks of purchasing, and etc. There is not much literature described relationships between product characteristics and perceived behavior control. Thus, we proposed the hypothesis 2 as follow:

H2: Characteristics of product have a significant impact on Perceived Behavior Control

Because TPB model offers a clearly defined model/structure that allows the investigation of the impact those attitudes, personal and cultural determinants and rational behavior control have on customers' behavior intention to buy environmental protection products, the model forms the theoretical structure of this study. TPB model was used to measure behavior intention of purchasing green products before (Alwitt et al., 1996; Chan, 2001; East, 1997; Diamantopoulos et al., 2003; Kalafatis et al., 1999). The hypothesis 3 to hypothesis 5 is described as follow:

H3: Personal Attitudes have a significant impact on Behavior Intention.

Consumers may perceive both difficulties and risk when considering buying green car, they can be expected to use their cognitive resources in forming beliefs toward the related attributes, which in turn may result in the development of an overall feeling (attitude) toward the behavior in question (refer to e.g., Antil, 1983; Zaichkowsky, 1985; Rossiter and Percy, 1987).

H4: Subject Norms have a significant impact on Behavior Intention.

Subjective norm, or the influence of others, has also been found to affect consumers' willingness to adopt a technology. Taylor and Todd (1995a, 1995b) reported that subjective norm positively affects consumers' adoption of innovative products. Green (1998) found that normative pressures have a significant positive effect on behavior Intention

H5: Perceived Behavior Control has a significant impact on Behavior Intention.

As the above-mentioned, TPB model is a perfect method to measure the key factors of behavior intention and causal relationships among aspects. The structure of this study is presented in figure 3 as follow. In the next section, we create questionnaires based on this model and past literatures.

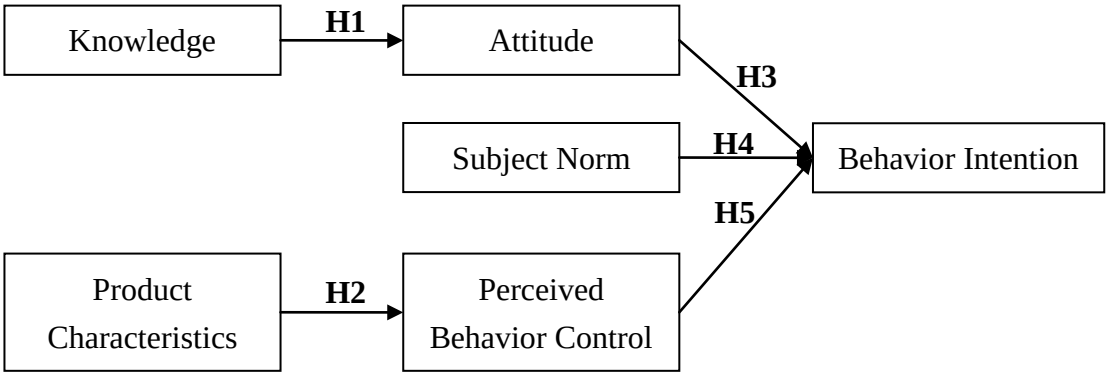

Figure 3. Research Model

RESEARCH METHODOLGY

Data collection

To empirically verify the proposed model, a comprehensive survey was conducted in Taiwan. Although English was initially used to develop the survey questionnaire, it was subsequently translated into Chinese to facilitate respondents' understanding. Linguistic equivalence between the English and Chinese versions was ensured by employing the back translation technique (Bhalla and Lin, 1987).

This study adapted the measures used to operationalize the constructs included in the investigated model from relevant previous studies, making minor wording changes to tailor these measures to the context of online shopping. The measures of actual usage, behavioral intention, perceived usefulness and perceived ease of use adapted from Davis (1993). The belief items for measuring compatibility, attitude, subjective norms, and perceived behavioral control were revised from Taylor and Todd (1995). Items for interpersonal influence and external influence were adapted from Bhattacherjee (2000), while items for measuring self-efficacy and facilitating conditions were adapted from Taylor and Todd (1995). All items were measured using a seven-point Likert-type scale (ranging from 1 = strongly disagree to 7 = strongly agree).

Data for this study will be collected as part of a larger mail survey of consumer perceptions

about green car purchasing. Participants were adults residing in Taipei, Taichung, and Hsin-Chu city. A three-page questionnaire was used as the research instrument. With the establishment of content validity, the questionnaire was refined through rigorous pre-testing. The pretesting focused on instrument clarity, question wording and validity. The pre-tested was performed in an iterative manner among a convenience sample of colleagues, students, and other consumers drawn from the general public. The 32 respondents of this test were asked to provide comments on the relevance and wording of the questionnaire items, length of the survey, and time taken to complete it. Based on the feedback, some of the questionnaire items were dropped. Further, the questionnaire layout was modified, and the wording of some of the questions was changed to improve clarity.

Multiple scale items, that were primarily adapted from Taylor and Todd (1995), were used to elicit respondents' salient beliefs, normative beliefs, self-efficacy, and attitude and intention towards green car purchasing. The instrument also included measures for assessing the level of green car purchasing and other relevant demographic indicators.

As a pilot test to gauge response rate, an initial mailing was sent to 120 of the randomly chosen sample. The survey package consisted of a cover letter, questionnaire, and pre-paid return envelope. A drawing to win one of NT$100 gift certificates, redeemable at shopping mall, was offered as an incentive to respond. As a reminder, a follow-up post-card was sent to all of the respondents a week after the initial mailing. Sixty one completed questionnaires were returned for a response rate of 56%. At the present time, 900 more survey was sent to the respondents via mail. After the collection of these survey questionnaires, the researcher will proceed to the statistical analysis.

Statistical analysis

The next stage, the hypothesized models are empirically tested using the structural equation modeling (SEM) approach, supported by LISREL 8.8 software with maximum likelihood estimation. Following the two-stage model-building process for applying SEM, the measurement model was estimated using confirmatory factor analysis (CFA) to test reliability and validity of the measurement model, and the structural model also analyzed to examine the model fit results of the proposed theoretical models.

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B3 – Innovations in higher education

B3.1 **Operational platform for the northern research and innovation**
Dr. Päivi Iskanius

B3.2 **Support for innovations in higher education in Poland under selected operational programmes since 2004**
Dr. Joanna Rakowska

B3.3 **The application of university classification for developing higher education institute performance indicators**
Suphattra Ketsarapong

B3.4 **Efficiency and effectiveness of public spending on higher education institutions**
Dušan Lesjak

OPERATIONAL PLATFORM FOR THE NORTHERN RESEARCH AND INNOVATION

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ABSTRACT

Northern Research and Innovation Platform is an operational platform for promoting northern know-how and expertise in the field of 'the environment, energy and natural resources' with a strong geographical emphasis on northern and arctic aspects. The platform brings together key research actors; universities and research institutes, universities of applied sciences and companies, in addition to other public organizations, aiming to generate multidisciplinary research projects and speed up innovations especially in the mining and new forest and bio-energy industries, but also in the field of emerging environmental technology industry. The platform also aims to support research in preventing environmental changes in the northern regions and in man's operational prerequisites in cold climate conditions. Further, the platform aims to increase the awareness and visibility of northern and arctic research within the local and national sphere, as well as within EU authorities, and to strengthen the influence on national and EU programmes. The platform acts as a channel between the regional actors and EU authorities. This paper presents the development work of the Northern Research and Innovation Platform and shows how the platform can be used as a tool for the promotion of research and innovation activities. The platform is based on the European Research Area (ERA) and Northern Dimension (ND), and it follows the recommendations given by Finland's Strategy of Arctic Region. The development work of the Northern Research and Innovation Platform is coordinated by the University of Oulu, Thule Institute, and financed by the European Regional Development Fund.

Keywords: Northern research and innovation, Platform, ERA, European Research Area, Northern Dimension, Finland's Strategy of Arctic Region

INTRODUCTION

The international interest in Barents region, North-western Russia and the entire Arctic region has risen during the past twenty years. The economic potential of these regions which are associated with natural resources; oil, gas, minerals, and new transport routes which may open because of the climate change, may underline the strategic importance of the region. The world heavily relies on fossil fuels to meet its energy requirements - fossil fuels such as oil, gas and coal are providing almost 80% of the global energy demands (Korhonen and Savolainen, 2001). On the other hand presently renewable energy and nuclear power are, respectively, only contributing 13.5% and 6.5% of the total energy needs (Asif and Muneer, 2006). The global demand for energy is increasing, and the northern regions, with their new energy sources, may become a major energy reserve for European Union (EU).

The growing exploitation of natural resources and enormous investments in energy and mining industries offers new business possibilities for northern EU countries such as Finland.

Such possibilities abound, e.g., in the arctic shipbuilding and offshore industries, fields relating to the construction of infrastructures in cold climate conditions, service production and fields relating to security, energy, data transfer and the environment. The transport and logistics sectors have particularly great growth potential when the Northeast Passage opens. Also, renewable energy sector is growing fast. The development and use of renewable energy sources, such as wind power, solar energy, hydropower, biomass energy and geothermal energy, can enhance diversity in energy supply markets, contribute to securing long-term sustainable energy supplies, help reduce local and global environmental impacts and provide commercially attractive options to meet specific energy service needs, particularly in developing countries and rural areas, creating new employment opportunities (Asif and Muneer, 2006). Along with the forms of energy which are currently used, the prospect of using wood, peat, logging waste, agricultural waste, industrial waste, household waste and crop plants as fuel or a source of heat and power has also become a tantalizing business opportunity (Korhonen and Savolainen, 2001).

Sustainable use of natural resources, preventing the climate and environmental changes and international emissions trading, and protecting the livelihood and culture of indigenous peoples require new technological, social and political innovations. For sustainable development, it is essential that the natural resources of northern regions are exploited in a controlled manner, taking into account economic, social, cultural and environmental impacts. Promoting innovations; include product, process and organizational innovations of an enterprise as well as social and institutional innovations at the level of industry, region and nation (Morgan, 1997), is one of the most important regional development policy devices (Kitson, et al., 2004), also for rural, sparsely populated areas such as northernmost regions of EU representing.

Rapidly growing industries, related to the utilization of natural resources, need skilled employees, and global level experts. These industries are highly location-specific and far from the global markets, which increases the need for new knowledge, research, and technology. Special emphasis needs to be placed on developing technology and know-how which is compatible with the northern and arctic conditions, improving the business environment, and pursuing national and international collaboration. Supporting fields of business which show an upward trend, identifying new priority areas and interdisciplinary research targets, and producing state-of-the-art research data for the use of companies and business life in the region is a special challenge for the northern universities and research institutes. Further, research actors and companies have to be tied into a common innovation process. It is generally conceded that the innovative performance of regions is improved when companies are encouraged to become better innovators by interacting both with various kind of support organisations (Lawton-Smith, 2000).

Innovation is highly localized process (Asheim and Cooke, 1999; Maskell, 2001). Innovations, whether they are radical technological advancements or incremental social and organizational changes – are also often done in networks, where actors of different backgrounds are involved in the interactive process (Asheim and Cooke, 1999). Innovations are made inside complex innovation systems, which are formed by industries, universities, venture capital organizations, governments and other public organizations. This paper presents the development work of the Northern Research and Innovation Platform and

shows how the platform can be used as a tool for the promotion of northern research and innovation activities. The platform brings together experts from different scientific and industrial fields, from different regions, and different organizations; universities and research institutes, universities of applied sciences and companies, in addition to other public organizations. It is an open forum for collaboration, coordination and an increase of sense of community of northern research, with a strong geographical emphasis on northern and arctic aspects.

The development of the Northern Research and Innovation Platform has started in northern Finland in the field of 'the environment, energy, and natural resources'. The platform aims to generate multidisciplinary research projects and speed up innovations, especially in the mining and new forest and bio-energy industries, but also in an emerging environmental technology industry. Further, the platform aims to support R&D activities in preventing environmental changes in the northern regions and in man's operational prerequisites in cold climate conditions. The platform aims to promote northern know-how and expertise on environmental and energy issues and the sustainable use of natural resources for the benefit of the whole of Europe, and thus meet European needs, by combining the environmental and social dimensions into technological expertise.

METHODOLOGY

The aim of this paper is to present the development of the Northern Research and Innovation Platform and show how the platform can function as a tool for the promotion of northern research and innovation activities. The development work has started in northern Finland in the field of 'the environment, energy and natural resources', but an international aspect was already taken into account at the start. The aim of the Northern Research and Innovation Platform is to act as an open forum for northern research actors in Northern Scandinavia, including Finland, Sweden and Norway, and also Russia.

The empirical data for this study has been collected by analysing the publicly available documents, by arranging five workshops, and by interviewing several experts in the field. The development work has been carried out during the years 2009-2011. The research questions are:

1. How is the Northern Research and Innovation Platform developed?
2. How can the platform be used as a tool for promoting northern know-how and expertise in the field of 'the environment, energy and natural resources?

First, in this study, the current state of northern Finland in the field of 'the environment, energy and natural resources' is presented, based on the publicly available documents. The most significant changes which have happened in the operational environment of Northern Finland are presented. These major changes in the operational environment of northern Finland must be taken into consideration and will direct the development of the Northern Research and Innovation Platform. Also, based on the analyses of industries, the field of 'the environment, energy and natural resources' is positioned within the other clusters and industries.

Second, in this study, the initiatives that the European Research Area (ERA), Northern Dimension (ND) and Finland's Strategy of Arctic Region have recommended for northern research and cooperation are analyzed. The platform is designed, based on the five initiatives of the ERA related to 1) researchers, 2) research infrastructures, 3) knowledge sharing, 4) joint programming, and 5) international cooperation. The platform follows the ND policy recommendations that encompass cooperation among various stakeholders in the innovation system; universities, research institutes, parliamentarians and business. Finland's Strategy of the Arctic Region states the targets for Arctic and northern know-how. These targets have been taken into account in the development of the platform content. Further, several national and regional strategies on northern research and know-how have been surveyed. Based on the literature survey, the basis for the platform is formulated and the targets and tasks are defined.

Third, in this study, the key research actors in the field of 'the environment, energy and natural resources in northern Finland' were identified. Based on the identification, the research community for workshops was formed. Five workshops were then arranged (9.6.2010, 17.8.2010, 5.11.2010, 21.1.2011). Totally 80 experts from different regions of the Northern Finland, from different scientific and industrial fields, and from different organizations; universities and research organizations, universities of applied sciences and companies, in addition to financiers and support organizations, were participated in the workshops. The objective of these workshops was to examine and make forecasts of the developmental trends affecting the northern regions, to analyze the manner in which the northern regions should prepare for various possible future developments, by focusing and integrating activities, as well as by developing research and infrastructures, to evaluate and support the development of a northern research and innovation system, and to support the drafting of a common vision and research agenda for the northern platform. Based on the workshop process, the following content of the platform is formulated; future research needs, cooperation methods, and the vision, strategy, research agenda and joint operational programme for the platform. Finally, in this study, the Northern Research and Innovation Platform is formulated. In this paper, the vision, objectives and tasks of the platform are presented.

THE FIELD OF 'ENVIRONMENT, ENERGY AND NATURAL RESOURCES' IN NORTHERN FINLAND

The current state of northern Finland

Northern Finland is the northernmost and one of the most sparsely populated areas in the EU. According to Statistics Finland, the land area is 156 000 km^2, over 50 per cent of the national territory, and the population is about 700 000, 13.6 per cent of the country's total population. The average population density is 4.7 people/ km^2. The region covers both rural areas and several small and medium sized cities. Most of the people live in urban regions. FUR Oulu is the largest centre with 220 000 inhabitants. The following five largest FURs; Rovaniemi, Kemi-Tornio, Kajaani, and Kokkola, each have 50 000–60 000 inhabitants. The remaining localities each have 20 000 inhabitants or less. The regions are also quite different in terms of human and economic resources. In FUR Oulu, the investments in R&D are 12.8

per cent of the national R&D funding, while the remaining localities have barely any investments in R&D at all (Statistics of FUR Oulu). All in all, northern Finland is a region of opposites with a strong concentration of high-tech manufacturing in the Oulu city-region, but, at the same time, possessing a strong role of agriculture and forestry as well as tourism in most of the other parts of the region.

The main challenges of the region stem from its peripheral location, harsh climatic conditions and sparse and rapidly ageing population. Young people, i.e. future potential experts, move away from the region in particular. One exception in northern Finland is the Oulu region, with its youthful age structure and high birth rate. Only a few Finnish city-regions have the necessary research base and knowledge producing organizations to support the innovation of world-leading industries, but the Oulu region in northern Finland is one of these. Most of the regions lack strong research and innovation environments. However, instead, they have a relatively strong capacity in non-scientific practice-based innovation. In order to succeed, northern Finland must lead the way on a global scale in selected sectors of innovation activity. (Iskanius, et al., 2010)

Northern Finland has a rich stock of natural resources. Industries which are related to natural resources include fossil and slowly renewable natural resources (metal ores, industrial minerals, natural stones, soil and rock materials, groundwater and peat), resources related to agriculture and forestry (wood, meat, milk and fur farming), as well as natural products and experience management (mushrooms, berries, lichen, hunting, fishing, tourism, reindeer farming) (Suorsa and Iskanius, 2010). The energy branch includes the production, transformation and delivery of energy as well as the refinement of fuels. In northern Finland, the focus in the energy field is concentrated especially in hydro-, wind- and bio-energy, as well as in the refinement of industrial wastes. Northern Finland has also been promised to be the location for a new nuclear power plant. The environmental sector includes the treatment and recycling of wastes, water and the waste water supply and sewerage, as well as the protection of air. The maintenance of biodiversity is also considered to be an important issue of research in the northern regions (Aarras et al., 2008; Pohjois-Pohjanmaan liitto, 2005). The enterprises in northern Finland are small. That is especially the case concerning business in the bio-energy sector, as well as in soil and rock materials. The latter also suffers from a lack of leading focal companies, as well as international marketing and productisation. In mining, most of the owner companies are international, and the raw material is processed outside the region. Based on the analyses of industries, the field of ‘the environment, energy and natural resources’ is positioned within the other clusters and industries (figure 1).

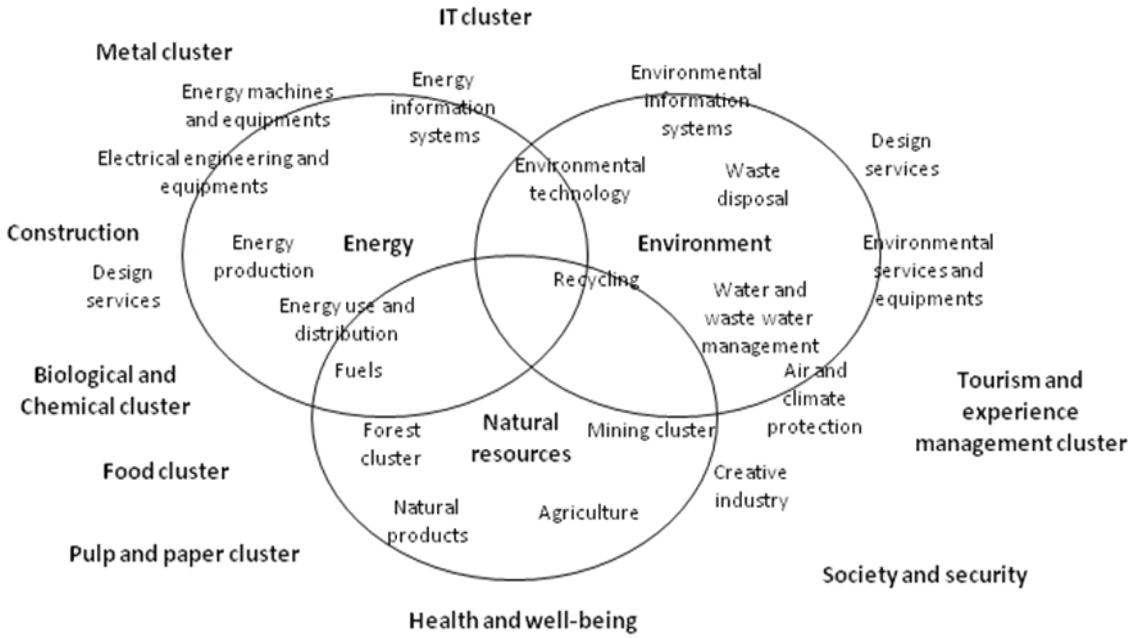

Figure 1: The field of 'the environment, energy and natural resources'.

Northern research

Northern research refers to research relating to the special conditions which are prevalent in the northernmost regions of the world. The primary special characteristics of the northern regions include a high sensitivity to the phenomena of global change, a cold climate, major seasonal variations in the amount of natural light, a low population density, a considerable diversity of cultures and identities, and rich natural resources. Northern research also looks at issues relating to global economy, society, social and regional development and their effects on the northern environment and communities (based on the Research Strategy Task Force of the Universities of Lapland and Oulu 2007 – 2008). Northern research is fragmented across various EU research programmes and research fields. Northern research has not been given due emphasis in the research policies of the EU. Northern research has been poorly coordinated in EU research policies, and EU funding for northern research has also been random and uncoordinated. According to Finland's Arctic Research Strategy (Korhola, 1999), the focus areas in the northern research are 1) Arctic natural resource research, 2) Global change and adaptation strategies in the arctic regions, 3) People and communities in the arctic regions, and 4) Arctic infrastructures.

From the viewpoint of the European research community, Finland possesses significant know-how and is the home to a large number of world-class research actors. Finnish northern and arctic expertise, know-how and research is internationally recognized. Finland possesses top-level arctic know-how in many sectors, eg. offshore industries, shipping industries, forest expertise, mining industry, metal industry, tourism, knowledge of traditional trades, low-temperature experise, winter testing, measurement technology, power and heat generation and distrubution, energy conservation and energy effidency, arctic wind power technology, arctic building and infrastructure, environmental engineering

and management of environmental impacts, sustainable social concepts, northern environmental expertise, northern health and well-being, waste management technology, informatioon technology and public e-services, innovation-oriented development, cold climate research, bio and nanosciences, risk analyses, oil spill prevention and response, material engineering (Finland's Strategy for the Arctic Region, 2010).

The research pertaining to nortehrn and arctic know-how and experiense is carried out in many universities and research institutes in Finland, however the universities of Oulu and Lapland, in particular, have been profiled as experts in northern and arctic research. Arctic Centre, University of Lapland, and Thule Institute, University of Oulu, have a leading position in the field. In August 2008, the universities agreed on a common strategy on northern research. It creates conditions for a regional (economic life, regional development organization), national and international network of northern research. In the annual negotiations between the Ministry of Education of Finland and the University of Oulu in April 2006, it was decided that; *"the university will focus particularly on northern global change research and on development of the Northern Research Platform of the European research area, thus supporting the EU's Northern Dimension Action Plan*".

Under the theme of global change in the northern regions, universities carry out top-quality research in the following sub-areas, which were supplemented by research concerning the Sami people in 2009:

- Natural systems: northern ecosystems, adaptation and climate.
- Environmental research and technology: natural resources, energy, land use, mining, tourism.
- The economy and judicial systems, societal and regional development: changes in the sources of livelihood, social structures and political structures.
- Art and culture: northern culture and history, minorities and indigenous peoples, northern art.
- Health and well-being: the significance of environmental factors and diet for health and well-being, indicators of health and well-being, social exclusion and special groups, special circumstances and adaptation.
- Methods and technologies: economical and judicial guidance, the interactions of art and technology, the identification and monitoring of change, remote sensing and geographic information systems, methodological and design-based research.

Research actors

Research is fragmented in the field of 'the environment, energy, and natural resources', both in terms of the themes and actors (figure 2). The northern research is carried out in two universities; University of Oulu and University of Lapland, but also in three university regional units/consortiums; Kajaani University Consortium, Kokkola University Consortium Chydenius, and Oulu Southern Institute; in five universities of applied sciences; Oulu, Kemi-Tornio, Rovaniemi, Kajaani and Central Ostrobothnia, and in several university research stations; Kevo Subartic Research Institute, Oulanka Research Station, Arctic Centre, Varrio Subarctic Research Station, Sodankylä Geophysical Observatory and Kilpisjärvi Biological Station. In addition, the northern research is carried out in several national research institutes; SYKE –Finnish Environment Insitute, METLA - Finnish Forest Research Institute,

MTT - Agrifood Research Finland, RKTL - Finnish Game and Fisheries Research Institute, GTK - Geological Survey of Finland, Evira - Finnish Food Safety Authority, VTT - Technical Research institute of Finland, STUK – Radiation and Nuclear Safety Authority, and Finnish Meteorological Institute (Suorsa and Iskanius, 2010).

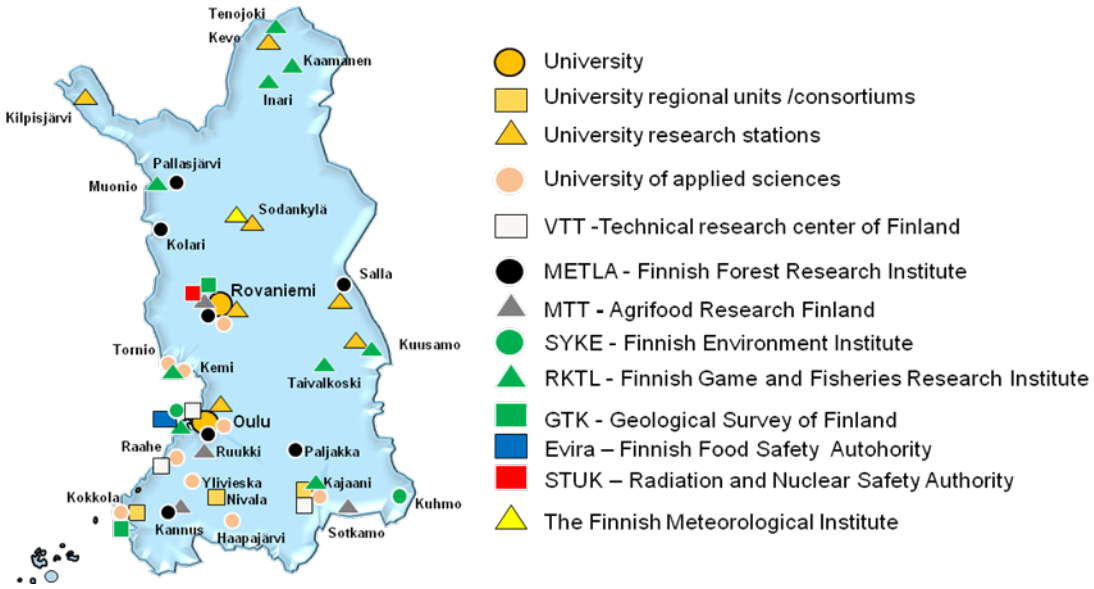

Figure 2: Northern research is fragmentated - over 50 different units/organistations.

In northern Finland, there are over fifty different research organisations/units in the field of 'the environnmet, energy and natural resources'. The research actors are small (staff <50) and they are located in various regions throughout northern Finland. However, small units tend to be more cooperative than large research communities. They are flexible in their decision-making and have a natural need for collaboration with others. The benefits which are reaped from collaborations are instantly visible as tangible increases in resources and know-how or as access to national and international research infrastructure environments or data. The research actors know each other, have few overlaps in their research efforts and already work together in various research networks. However, most future research needs are likely to involve more than one scientific discipline or field. Thus, greater effort should be made to increase interdisciplinary cooperation. For instance, the utilization of information technology in some of the more traditional fields might give rise to new innovations and business opportunities. Fragmentation creates specific challenges for multidisciplinary cross-scientific research, as well as research carried out in collaboration with business life. For strategic reasons, universities and other institutes of higher education have agreed on organization-specific responsibility areas in education and research, as well as on the forms of cooperation between the various research fields (based on the strategies of. Lapland University Consortium 2009 and the report of cooperation project of the universities of Oulu and Lapland 2007-2009). Also, in the NorNET- Northern Environmental Research Network cooperation, national research institutes aim towards a more coordinated research in the field of the environment and natural resources.

However, coordination, collaboration and the sense of community is still lacking. The collaborative networks of these research actors should be tightened, and their roles and responsibilities are in need of clarification. Particular attention should be paid to intensifying the collaboration between the public and private sectors, universities, universities of applied sciences and technology centers. Coordination is needed, and research activities should also have a clearer focus. While one cannot be an expert on everything, even relatively small competence clusters can represent top international expertise in a few carefully selected fields.

STRATEGIES BEHIND THE NORTHERN RESEARCH AND INNOVATION PLATFORM

ERA, European Research Area

The European Research Area (ERA) was launched in 2000 for composing of all research and development activities, programmes and policies in Europe which involve a transnational perspective. The ERA provides attractive conditions and effective and efficient governance for doing research and investing in R&D intensive sectors in Europe. It creates strong added value by fostering a healthy Europe-wide scientific competition whilst ensuring the appropriate level of cooperation and coordination. It is responsive to the needs and ambitions of citizens and effectively contributes to the sustainable development and competitiveness of Europe. Europe 2020 – Smart, Sustainable and Inclusive Growth Strategy is integrated into the development of ERA. The target is; that by 2020, all actors fully benefit from the "Fifth Freedom" across the ERA: free circulation of researchers, knowledge and technology. The EU Research Framework Programmes were designed to support the creation of ERA. ERA was established to address the weaknesses of European research activities, such as insufficient funds, the lack of a suitable environment for conducting research and exploiting the results, and the fragmentation of research activities and resources. The last two apply in particular to the northern regions. ERA aims at creating a unified, frontier-free zone, allowing a more efficient pursuit of research activities and the utilization of scientific resources for the ultimate goal of boosting employment and competitiveness in Europe. International cooperation, the free movement of competent researchers between countries, top-class research environments and research institutes, the sharing of knowledge, coordinated research programmes and an openness towards the rest of the world are important tools in creating a common research area. ERA aims to increase cooperation in five areas; 1) the careers, working conditions and mobility of researchers between different sciences, industrial fields and states; 2) the creation of world-class European research infrastructures, 3) the transfer of knowledge 4) the joint design and operation of research programmes and cooperation between public research and industry; and 5) the international cooperation in science and technology. (European Research Area, 2011)

ND, Northern Dimension

EU is closely linked with the northern and Arctic regions owing to political, geographical, economic and scientific factors. The impact of the EU's policies and decisions also extend to the northern regions. An example of this is the Northern Dimension (ND) policy, which was elaborated in 1999 with the participation of Norway, Iceland, EU Member States and the

Russian Federation. The USA and Canada hold observer status. The main objectives of the ND policy are to provide a common framework for the promotion of dialogue and concrete cooperation, strengthen stability and well-being, intensify economic cooperation, and promote economic integration, competitiveness and sustainable development in Northern Europe. Related to the northern research and innovation, The ND also encompasses the 'Arctic window', which means cooperation on issues concerning the whole circumpolar Arctic region. The core of the ND policy for research is the encouraging cooperation is mutual dependence between the EU and Russia in the joint border regions. Besides cooperation between governments, ND also supports the cooperation between universities, research institutes and politicians and industry. Also, Northern Dimension Institute was established for university networking to help coordination of research and education, and to get funding for research projects. (Northern Dimension, 2009)

Finland's strategy for the Arctic region

Finland has recently published Finland's Strategy for the Arctic Region, the main objectives of which are, related to the science, to give stronger support for northern research, the development of regional climate models and the long-term monitoring of the state of the environment as the basis for decision-making, and to reinforce the national coordination of research and monitoring. Finland's objectives are to strengthen Finland's role as an international expert in arctic knowhow by investing in education, research, testing, technology and product development, to make better use of Finnish experience of winter shipping and arctic technology in arctic sea transport and ship building, and to improve the opportunities of Finnish companies to benefit from their arctic knowhow in the large projects undertaken in the Barents Region by supporting the networking, export promotion and internalization of small and medium size enterprises, in particular. According to Finland's Strategy for the Arctic Region (2010):

- The arctic region has considerable economic potential. The increase in maritime traffic in the Arctic Ocean and exploitation of natural resources are an opportunity for Finnish expertice.
- Maintenance and further develpoment of arctic know-how, research and special experience require strategic choices and decisions on the part of Finland, and also relevant university-level education, correctly targeted investments and national and international cooperation.
- The development of know-how and technologies applicable to Arctic circumstances in the global operating environment highlights the importance of institutes of higher education.
- Competition is increasingly based on skilled labour and research resources in addition to market shares and capitals.
- The supply of new information and skills, and their diverse utilisation, will also lay the foundation for success in the future.
- The changes that have taken place in the operating environment require that universities accelerate their internationalisation efforts and resources are increased and focused on core strengths.
- International cooperation is a means of improving quality, eliminating overlapping activities, and gathering domestic and foreign resources for joint projects.

- Top-level competence is necessary when seeking interaction with leading global centres and actors.
- Finland has an extensive research infrastructure and a wide network of research stations.
- It is important that the national input into multidisciplinary scientific research continues.
- Guaranteeing broad-based Arctic research competence requires that universities and research insitutes emphasise their expertise in their strategies and activities and make use of the funding opportunities offered by the Academy of Finland and the EU Framework Programmes for research.
- Research and development bring economic benefits but also support environmental protection and the discovery and spread of best practices.

Essential targets of the northern research have been summarized based on the Finland's Strategy for the Arctic Region (2010):

- Owing to climate change and international emissions trading, environmental technology has the potential of serving as an engine in the expoert sector.
- Research plays a key role in adaptation to Arctic climate change and in the utilisation of opportunities offered by the Arctic region.
- The environment is fragile in the Arctic, including Northern Finland.The principal problems include climate change, the environmental impacts caused by increased shipping and exploitation of natural resources, reduced biodiversity, long-range transportation of pollution and issues pertaining to nuclear safety.
- The research carried out in Finland, especially in the monitoring of the state of the environment and in collecting long-term research material, has world-class relevance.
- The improvement of transport, communications and logistics links and simpler border formalities are key factors for the development of Northern Finland.
- The Sami in Finland are the Arctic indigenous people, whose status has been secured in the Constitution.

Finland's Strategy for the Arctic Region (2010) also promotes Finland's interests within the EU at a time when the EU is formulating its own Arctic policy, and specifies Finland's views in relation to the Arctic policies of other countries. According to the Communication from the Commission to the European Parliament and the Council – The European Union and the Arctic Region (2008), the European Community should maintain the arctic region as a priority area for research to close knowledge gaps and assess future anthropogenic impacts, especially in the area of climate change. The proposals for action include, for instance, developing further research programmes, assessing the state and evolution of the arctic environment, creating a new research infrastructure and enhancing monitoring and surveillance capabilities, and coordinating efforts in different research areas relevant to the arctic region, as well as developing arctic technologies.

Finland's Strategy for the Arctic Region includes a large variety of goals relating to the northern research and know-how. However, there are some important issues which are not covered by the strategy. The Northern Research and Innovation Platform aims to contribute to a part of these goals:

- Finland should make the northern regions a priority area for research, and additional resources should be earmarked for these activities in the governmental budget. Finland should also lobby for the European Union and other international actors to channel more resources into research carried out in the northern regions.
- Research should be integrated with environmental, foreign and industrial policies as this promotes collaboration between science and industry.
- New opportunities generated by interdisciplinary approaches should be exploited.
- Integration and the strategic development of northern infrastructures should be pursued.
- Networks should be created between regional research clusters, and a competence area focusing on northern know-how should be established.
- The knowledge and skills of people living in the northern regions, especially those of the indigenous peoples, should play a role in the development of the northern regions.
- Finland should shoulder its share of the global responsibility, i.e., be "a caring mediator".

NORTHERN RESEARCH AND INNOVATION PLATFORM

The Northern Research and Innovation Platform is based on ERA and ND (figure 3). The platform is formed by analyzing the five areas of ERA; 1) researchers, 2) research infrastructures, 3) the transfer of knowledge, 4) joint design programmes, and 5) international cooperation in science and technology. Further, the platform follows the ND policy recommendations that encompass cooperation among various stakeholders in the innovation system. Finland's Strategy for the Arctic Region includes a large variety of goals relating to the northern research and know-how, which has been taken into account in the development of the platform content. Also, there are some important issues which are not covered by the strategy. The platform aims to contribute to a part of these goals.

The Northern Research and Innovation Platform is a platform for promoting northern know-how and expertise in the field of 'the environment, energy and natural resources' with a strong geographical emphasis on northern and arctic aspects. The platform brings together key research actors; universities and research institutes, universities of applied sciences and companies, in addition to other public organizations, aiming to generate multidisciplinary research projects and speed up innovations, especially in the mining and new forest and bio-energy industries. Further, the platform aims to support research in preventing environmental changes in the northern regions and in man's operational prerequisites in cold climate conditions. The platform also operates in the field of emerging environmental technology, focusing on, e.g., material and energy efficiency, renewable energy solutions and waste management, as well as water and waste water treatment, air protection, environmental measuring, monitoring, and analysis, environmental law and sustainable economy, and climate-friendly and cost-effective processes, automation and services.

The Northern Research and Innovation Platform will develop know-how and expertise on the environmental and energy issues and the sustainable use of natural resources for the benefit of the whole of Europe, and thus meet European needs by combining the

environmental and social dimensions into technological expertise. The platform also aims to increase the awareness and visibility of northern and arctic research within the local and national sphere, as well as within EU authorities, and to strengthen the influence on national and EU programmes. The platform can act as a channel between the regional actors and EU authorities.

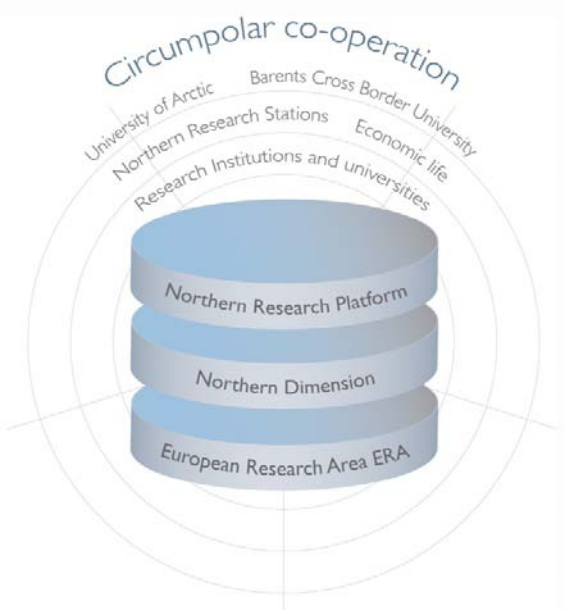

Figure 2: Northern Research and Innovation Platform.

Based on the ERA, ND and Finland's Strategy for the Arctic Region, the Northern Research and Innovation Platform is formulated:

1) The platform is an open forum for new partnerships between research actors, companies and the public sector in northern Finland. The platform encourages people living in the northern regions, especially those of the indigenous peoples, to share their knowledge and skills in the development of the northern countries. The platform encourages researchers and other experts to circulate and to cooperate across scientific, organizational, regional and national borders and to create transnational, multidisciplinary research groups.
2) The platform supports the development and operation of common research structures in northern Finland. The platform aims to make the northern regions a priority area for research, and recommend that additional resources should be earmarked for these activities in the governmental budget. The platform develops an infrastructure of electronic communication and promotes international networking.
3) The platform provides access for northern know-how and experience and promotes the collaboration between science and industry. The platform disseminates the results of publicly funded research to make them more exploitable, allowing them to be refined into new products and services.
4) The platform increases collaboration, coordination and the sense of community in a fragmented field of research actors. The platform actors participate voluntarily and variedly in defining, developing and implementing a common strategic framework for northern research. A shared vision on how the great societal and scientific challenges should be addressed serves as the platform's foundation.

5) The platform promotes collaboration in northern research and also creates new connections to neighbouring countries, while strengthening those that already exist. In collaboration with international partners, the platform will actively participate in addressing the challenges which are typically present in the northern regions. The platform strengthens the northern negotiation power to have an influence on the contents of national and international/EU programmes. The platform is a channel between region and EU and other international actors to channel more resources into research carried out in the northern regions. The platform develops recommendations, detailing specific tasks, approaches, participants and the necessary infrastructure for the national and EU programmes, such as FP 7 and the forthcoming FP 8.

Northernmost Europe's future growth, competitiveness and sustainability objectives are dependent upon major research, innovations and technological advances in the medium to long term. The platform will promote the creation of new partnerships between universities, research institutes and companies, draft, in the first stage, a co-operation strategy for research and development from the regional and national starting points and links it with international strategies. The platform will play a key role in ensuring an adequate focus of research funding on areas with a high degree of industrial relevance, by covering the whole economic value chain and by mobilizing public authorities at national and regional levels. In fostering effective public-private partnerships, the platform has the potential to contribute significantly to the renewed Lisbon strategy and to the development of a ERA of knowledge for growth. As such, they are proving to be powerful actors in the development of European research policy, in particular in orienting the national and international research programmes better meet the needs of industry in the field of environment, energy, mining and forestry.

CONCLUSIONS

The Barents region, North-western Russia and the entire Arctic region offer extensive business opportunities especially in the sectors of shipbuilding and offshore industries, sectors associated with the building of infrastructure, and in the sectors of the environment, security, energy, and telecommunications. For sustainable development, it necessary to pay increasing attention to environmental protection, and thereby, also to the preservation of healthy living conditions for indigenous peoples and other inhabitants in the northern regions. Environmental issues are not just a separate sector of their own; instead, they are an important element of a wider whole. Because climate change and other environmental hazards are not contained by national borders, international cooperation for prevention is vitally important. The environmental problems in the northern regions must be identified and tackled in the close cooperation among all actors in the northern regions, by launching transnational, multidisciplinary research projects, and by making the implementation of international treaties more efficient.

There is a strong increase in the demand for northern and arctic know-how and technologies. The feasibility and use of technological solutions and tools related to the sustainable use of northern natural resources and the preventing and adapting to climate

and environmental change must be studied. Economic, technological and social innovations arising from this process must be developed. Controlling northern environmental issues contains business opportunities which offer an important way to solve these issues. The need for problem-oriented multidisciplinary research has increased, and solving research problems requires more and more cooperation these days. The need for international centers of excellence is on the rise. The small number of businesses is a weakness for northern Finland. This creates a need for new methods of action to transform research-generated ideas and inventions into commercial profits. The productisation of northern know-how has also become a high priority.

Issues which are related to the sustainable use of 'the environment, energy, and natural resources' are usually politically and emotionally charged. Furthermore, different sources provide conflicting information, e.g., on how non-polluting the various production processes are, how sustainable the use of various natural resources is, and what the practical implications of climate change actually are. More impartial information and open discussions are required on these topics to allow an economically, environmentally and socially sustainable use of natural resources in the northern regions. People who live in the region tend to see the close proximity of, e.g., mines, waste incineration plants or nuclear power plants as a threat to their personal health and well-being or the region's other businesses, such as tourism. This is why we need information about the true impact of different industries and should also be on the lookout for possibilities to develop production methods and make them more ecologically sound. This is important in order to avoid pitting the region's different businesses (industry, reindeer management, tourism etc.) against one another.

The northern research actors are small compared to their Central European competitors, which encourages cooperating and networking. Improving coordination of northern research will add interest in this horizontal area of research on a national and international level. This will provide northern research with more resources which can be targeted on research benefiting the economic life and developing new innovations. Thus, northern research will offer better support for regional innovation activity and regional entrepreneurship, and promote equal regional development.

The Northern Research and Innovation Platform is not ready, but it has already adopted some specific characteristics when compared to the other actors in the northern research and innovation community. The activities will stretch over the entire circumpolar belt, and connect universities and the regions, from Canada to Sweden, from Japan to Russia, and Iceland, Finland. Compared to the other research actors or networks in the north, the platform is market-driven, down-up processes, and is also more focused to how research results can benefit the business world around the research institutes. In summary, the Northern Research and Innovation Platform supports the following activities:

- Scientific collaboration between various scientific disciplines, research institutes and industries should be increased.
- Scientific and infrastructure collaboration (logistic arrangements, research-related infrastructures) with other research institutes in the northern regions (Norway, Sweden, Russia, Canada, Iceland, Greenland, the Faroe Islands) should be increased.

- EU subsidies and programmes targeted at the northern regions should be exploited more efficiently.
- The European Union should be made aware of northern research needs.
- Existing networks and projects, and the results generated by them, should be utilized more efficiently.
- Impartial information (concerning different forms of energy in particular) should be generated and disseminated.
- Regional strengths (minerals, geo-energy, water, ICT) should be utilized better, and their true potential should be explored.
- More emphasis should be placed on value chain thinking: the possibility to establish new networks and adopt a perspective of sustainable production and product development.
- Education and know-how should be increased and developed by educational institutions as well as the exploiters of research and education (companies, decision-makers, officials) – targeted training based on regional needs, training for top experts/researchers, the ability to accept new information.
- Educational collaboration should be increased both internationally and between various northern organizations.

The Northern Research and Innovation Platform strongly supports the action proposal of Finland's Strategy of Arctic Region, i.e., that the Academy of Finland should launch an arctic research programme with a special emphasis on multi- and interdisciplinary research and international collaboration, in order to safeguard Finland's extensive competence in arctic research. Finland's Arctic Research Strategy is from the year 1999. Responding to today's changing circumstances and financial situation through research requires an update to the new national northern research strategy and the adoption of a new approach based on Finland's Strategy for the Arctic Region. Vital important is also to influence on matters relating to research and know-how in the coming EU Arctic Strategy and commit the action proposals of the Northern Dimension policy. The Northern Research and Innovation Platform may create a certain kind of EU Gateway status for the Barents region, North-western Russia and the entire Arctic region related to the northern and arctic research and innovation.

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SUPPORT FOR INNOVATIONS IN HIGHER EDUCATION IN POLAND UNDER SELECTED OPERATIONAL PROGRAMMES SINCE 2004

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ABSTRACT

The paper refers briefly to main definitions and categories of innovations defined in literature. Next it synthesizes rationale for supporting innovation in education expressed in OECD, EU and Polish strategic documents and presents goals of these strategies towards combined key elements of knowledge triangle: innovation, research and education. Empirical part of the elaboration presents findings of qualitative and quantitative analysis of innovative projects carried out by tertiary education institutions (TEI) under selected operational programmes over 2004-2006(2009) programming period. Selected TEI innovations were categorised, classified and grouped according to criteria defined in literature. Quantitative analysis focuses on financial effects of discussed projects. Author also discusses directions of support for innovations under sectoral operational programmes over on-going 2007-2013 programming period.

Key words: innovations, higher education, sectoral operational programmes.

INTRODUCTION

Development of many EU countries has advanced to innovation-driven stage. Hence, investment in innovations – next to research and technology - is essential to economic growth (Varis, 2007). However, it is people – human capital - who generate innovative knowledge and ideas, and it is people who implement and apply all kinds of novelties in the workplace and in society (OECD 2011). That is why support for innovative economy should begin with support for innovative education.

Human capital is formed basically by formal education. Especially higher (tertiary) education is indicated as an element playing crucial role in the process of building innovative society. And it should be stressed that tertiary education institutions such as academia and universities take here a double role. Firstly, in the process of education they produce human capital which is able to create and/or absorb and disseminate innovations. Secondly, these institutions still remain main research centres, on one hand providing innovations and on the other hand providing information on changes in this field, because they carry out research both *on*[1] and *in* innovations (Meek et al., 2009).

The above has been acknowledged by many international organisations, EU institutions and EU Member State governments, including Poland. However Polish tertiary education has to

[1] 'It is not surprising that research on innovation has gained importance: it has become essential to understand why and how certain enabling environments encourage innovation and help optimize its various benefits. Among other things, research can identify how knowledge translates into innovative action and how diversity can drive positive change'. (Meek et al., 2009)

face not only challenges of innovation-driven economy, but also those resulting from long-lasting negative effects of centrally-planned economy and next from difficult transformation process. That is why Polish tertiary education does need support to become an engine for innovative society and knowledge-based economy.

After accession, EU funds became very important for the development of Polish research and tertiary education. According to the opinion of Polish Ministry of Science and Higher Education (2010) these funds are at present the main support for innovation and research, for creating modern infrastructure of science, for modernising universities and improving the education process.

METHODS

The presented analysis was based on data provided by the Ministry of Regional Development, which is the main national institution responsible for implementation of Sectoral Operational Programmes (SOP) in Poland. The basis comprises of 87909 records describing the value, thematic field, action and sectoral operational programme for each project carried out over 2004-2006(2009) under all seven SOPs. As no detailed data is disseminated for 2007-2013 programming period, this part of elaboration is based on general reports of the Ministry of Regional Development and the Ministry of Science and Higher Education.

The applied research method consisted of both qualitative and quantitative data analyses. First stage comprised of the standard method of qualitative data analysis e.g. data coding, categorisation, sorting and reduction (Miles and Huberman 1994). All applied criteria were *a priori criteria*, e.g. criteria classifying innovations as product, marketing, process and organisational ones emerging from the innovation theory [Oslo Manual, 2005] or criteria defining soft and hard projects, presented in literature (Crawford and Pollock, 2004). Coding used at all stages was based on main categories (*non-hierarchical (flat) coding).*

The research process began with selection of projects meeting the main criterion: they had to be projects carried out by tertiary education institutions (TEI) as beneficiaries of Operational Programmes over 2004-2006.

The next stage focused on selecting projects resulting in implementation of innovation.

The list of selected innovation projects carried out by TEI was sorted into groups of projects under specified operational programmes. Thus obtained and categorised research sample was coded according to Oslo Manual criteria. Based on the results of coding, the projects were categorised again into four groups: product, process, organisational and marketing innovations.

Quantitative analysis focusing on the financial effects of the support for innovations in education was the last stage.

THEORETICAL FRAMEWORK AND PRACTICAL BACKGROUND FOR INNOVATIONS

Definitions and categories of innovations

There are numerous definitions of innovation in academic literature. Each of them reveals different important aspects of innovations, but the most applicable ones - from the point of view of this elaboration - are those presented below.

The classical definition by Schumpeter (1934) says that innovation is an introduction in the market of a new product or process which provides new distinguishing elements versus the existing ones. Schumpeter identified innovation as the critical dimension of economic change.

In 'Green Book on Innovation' (1995) European Commission referred to the term of innovation as 'renovation and expansion of the range of products, services and the corresponding markets', 'renovation of the methods of production, supply and distribution' and 'changes in management, working organization, working conditions and qualifications of workers'. Such approach seems to reflect quite closely the definition of OECD and Eurostat.

Oslo Manual (OECD, Eurostat, 2005) defines innovation as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations. Thus, all innovations must contain a degree of novelty. And according to the criterion of novelty the innovations can be classified into three groups:

i) innovations new to the firm (diffusion of an existing-in-the-market innovation to a firm),
ii) innovations new to the market (the firm is the first to introduce the innovation on its market) and
iii) innovations new to the world (the firm is the first to introduce the innovation for all markets and industries).

Oslo Manual also defines four other types of innovations. These are:

- A product innovation, which is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. Product innovations can utilise new knowledge or technologies, or can be based on new uses or combinations of existing knowledge or technologies. Product and/or service innovation entails activities such as design, research and development, acquisition of patents, technology licenses, trademarks, and tooling-up industrial engineering.
- A process innovation, which is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. Process innovations can be intended to decrease unit costs of production or delivery, to increase quality, or to produce or deliver new or significantly improved products.
- A marketing innovation, which is the implementation of a new marketing method involving significant changes in product design or packaging, product placement,

product promotion or pricing. Marketing innovations are aimed at better addressing customer needs, opening up new markets, or newly positioning a firm's product on the market, with the objective of increasing the firm's sales.

- An organisational innovation, which is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations. Organisational innovations can be intended to increase a firm's performance by reducing administrative costs or transaction costs, improving workplace satisfaction (and thus labour productivity), gaining access to non-tradable assets (such as noncodified external knowledge) or reducing costs of supplies.

European Commission suggested another classification of innovations, based on findings of evaluation of Employment and ADAPT Programmes. These are:

i) process-oriented innovations: development of new and/or improvement of already existing methods, instruments and approaches;
ii) target-oriented innovations: setting up new objectives and approaches in order to identify new possibly successful qualifications and creating new jobs on the labour market;
iii) context-oriented innovations: developing political and institutional structures in the labour market.

Innovation can occur in any sector of the economy, including government services of which education is of special focus herein. Although the theoretical framework applies mostly to business innovations, its elements can also be used to define and classify the concept of innovations in education.

Plaza (et al., 2010) analysed the concept of innovativeness in the context of university education. They came up with the following examples:

i) product innovations: creating new teaching materials (books, lecture notes, educational software) and/or improving the existing ones, ICT (Information and Communication Technologies) play an important role;
ii) process innovations: novelties in the teaching-learning process (updating teaching methodology);
iii) organisational innovations: as there are different levels of organization at universities (faculties, departments, areas, lecture rooms, etc.) the innovation may involve improvements in the human resources management, infrastructure, internal organization, etc.

Although not mentioned in the above discussed elaboration, in Poland we can observe also marketing innovations at some universities competing for and trying to attract prospect students. This is caused by negative demographic change and decrease in the number of young people.

Innovation rarely occurs in isolation; it is a highly interactive process of collaboration across a growing and diverse network of stakeholders, institutions and users (OECD, 2010) and education is of major importance in this growing and diverse network.

International, European and Polish rationale and strategies for innovations in education

The advent of the information and knowledge-based society is a major event for innovation (Council, 2011), but it is a challenge as well.

If higher education is to play a role of instrument creating innovative attitudes among young people, then its statistics are vital. In OECD member countries one-third of 25-34 year-olds have a tertiary education now, however young people graduate in social sciences, business and law increasingly, while there is a decline in the share of science and engineering graduates in a number of countries, including Poland. This phenomenon is definitely limiting the future innovative potential of human capital. Educationally inactive youth, tertiary drop-outs and poor literacy levels suggest that OECD countries still have a lot to do to raise educational attainment (OECD 2011) and so has Poland.

To address these challenges, OECD (2010) elaborated five main policy principles for innovation:

i) Empowering people to innovate (education and training systems should equip people with the foundations to learn and develop the broad range of skills needed for innovation in all of its forms, and with the flexibility to upgrade skills and adapt to changing market conditions. To foster an innovative workplace, ensure that employment policies facilitate efficient organisational change);
ii) Unleashing innovations;
iii) Creating and applying knowledge;
iv) Applying innovation to address global and social challenges;
v) Improving the governance and measurement of policies for innovation.

Very similar attitude to innovation as a driver of economic growth and a way to address global and social challenges is taken by EU. Innovation, together with research and education make three central and strongly interdependent drivers of the knowledge-based society and are referred to as the 'knowledge triangle'. The convergence of higher education, scientific research and innovation systems which have now become strategically interlinked in terms of their objectives and modalities generates synergy (Plaza et al., 2009). These three key concepts creating knowledge triangle should be better linked together to reach the objectives of Lisbon Strategy and of Strategy Europe 2020 (European Commission, 2010).

Goals of EU's Lisbon Strategy aim to deliver stronger, lasting economic growth and to create more and better jobs thus making EU the **'**most dynamic competitive knowledge-based economy in the world'**.** Innovation is indicated as an instrument enabling to achieve these goals through contribution to creating new jobs and industries.

Strategy Europe 2020 puts forward three mutually reinforcing priorities, among which smart growth priority aims at developing economy based on knowledge and innovation[2]. The

[2] 'Europe's education and training systems need to provide the right mix of skills and competences, to ensure a sufficient supply of science, mathematics and engineering graduates, to equip people with basic skills and the motivation and capacity to learn, to foster the development of transversal competences, including those

Commission also proposed the following EU headline targets that should be achieved by 2020:
– 75 % of the population aged 20-64 should be employed;
– 3% of the EU's GDP should be invested in R&D;
– the "20/20/20" climate/energy targets should be met (including an increase to 30% of emissions reduction if the conditions are right);
– the share of early school leavers should be under 10% and at least 40% of the younger generation aged 25-34 should have a tertiary degree;
– 20 million less people should be at risk of poverty.
It was highlighted (Council, 2010) that measures taken in the education and training sector will contribute to achieving the targets in other areas, such as increasing employment rates, promoting research and development, and reducing poverty.

To achieve the above goals and progress under each priority theme the Commission put forward seven flagship initiatives, of which 'Innovation Union' is meant to improve framework conditions and access to finance for research and innovation in order to ensure that innovative ideas can be turned into products and services which create growth and jobs.

Boosting innovative ability in Europe can be done by bringing together enterprises and research centres or universities, developing systems of education and training, emphasising the local and regional level, fostering mobility among students and research workers or disseminating "technology watch" results (Council, 2010).

Since its accession to EU in 2004, Poland faces the same challenges as the whole Community and is obliged to aim at achieving the same educational, research and innovation targets strengthening knowledge triangle. But the social and economic situation of Poland differs significantly from those in old Member States. The deep development disparities result from both unfavourable inheritance of centrally planned economy and from difficult transition process.

Comparing Polish economy to economies of other EU countries proved that if Poland wants to make up the economic gap separating it from richer EU States, it will have to considerably increase innovativeness of its economy. It was assumed in government documents that global economy based on knowledge and ITC technologies demands teaching new skills in all professions, both the traditional and new ones. Thus 'education today must teach for the economy tomorrow', and this means that it should strengthen analytic skills, develop innovation talents and entrepreneurship (Ernst&Young and IBnGR, 2010b; KRASP 2009).

Polish tertiary education institutions are not ranked satisfactorily in international ranking lists, where research achievements are one of the main criteria. It results mainly from the government policy implemented over the last two decades, where the priority was to educate more and more people to improve catastrophically low indices of scholarisation

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that enable the use of modern digital technologies, to promote sustainable development and active citizenship, and to encourage creativity, innovation and entrepreneurship' (Council, 2011).

inherited after the previous system[3]. This 'quantitative' approach was realized in conditions of dramatically low and still decreasing national budget expenditure on R&D. Now there is an urgent need to reform Polish higher education system in order to assure its better quality through its adjustment to the needs of knowledge-based economy.

The same need has had to be addressed by most industrialized countries, who have been obliged to address the double challenge of providing wider access to tertiary education as well as training and ensuring adequate investment in high-level research. Governments pursue reforms to build world-class system of higher education, to assure quality in both research and teaching.

According to ongoing discussion and public debate in Poland, the new reformed tertiary education should perform three main functions: generating knowledge (research), transferring knowledge (education) and applying knowledge (innovations). Thus implementing the idea of knowledge triangle and becoming a more effective part of the European Research Area and European Higher Education Area (Ernst&Young and IBnGR, 2010a). The reform also aims at promoting reinforced cooperation between higher education institutions, research institutes and enterprises with a view to strengthening the knowledge triangle as the basis for a more innovative and creative economy (Council, 2011). However the issue of lack of funds necessary to improve innovations in educational system in Poland still remains unsolved.

STRUCTURE AND NUMBER OF STUDENTS IN TERTIARY EDUCATION INSTITUTIONS AND CHANGES OVER 2004-2009

According to the data from the Central Statistical Office of Poland, there was a significant change in the number of tertiary education institutions and their students between 2004 and 2009 (the latest available data). In 2004 in Poland there were 420 TEI which educated 1.91 million students, in 2009 the number of TEI increased to 454 (i.e. by 8.1%) while the number of students decreased to 1.88 million (i.e. by 1.7%).

The structure of TEI changed significantly over that period. The number of universities increased by two (to 19 in total), but they lost 3.5% students when compared to 2004. The same trend is observed in case of higher technical schools: 23 in 2009 (increase by one) and decrease in the number of students by 6.7%, which is a very undesirable tendency from the point of view of EU's educational objectives aiming at the increase in the number of graduates from technical tertiary schools. Next there was increase in the number of pedagogical TEI (to 18), while the number of their students decreased by 20.2%, and similarly in case of 15 theological TEI (increase by one) which in 2009 were educating 29% less students than in 2004.

[3] Paradoxically enough, some authors argue (Ernst&Young and IBnGR, 2010b) that ageing of the society may cause desirable changes in higher education as decreasing number of young people will force universities to compete for students, offering a high quality education, hopefully. The number of young people aged 18-24 is forecast to decrease till 2020 by 1.5 million, while the number of students will decrease by 600-800 thousand, assuming that scholarisation index remains on the same level.

Another group consists of two categories of TEI, economic and agricultural ones. The number of economic TEI decreased by 13% (from 93 in 2004 to 80 in 2009) and the number of their students decreased by 20.1%. There are also two agricultural TEI less (7 in 2009), and the number of their students decreased by 24.5%.

Although the number of medical (9) and physical training (6) academies did not change, they educate more students: medical academies 26% more and PT academies 5% more in 2009 than in 2004.

The most numerous is the group of 254 Public (State) Higher Education Vocational Schools which had 407.4 thousand students in 2009. They replaced Higher Education Vocational Schools which had 207.1 thousand students in 2004.

EFFECTS OF SUPPORT FOR INNOVATIONS IN HIGHER EDUCATION IN POLAND UNDER SELECTED OPERATIONAL PROGRAMMES 2004-2006(2009)

Over 2004-2006(2009) public and private tertiary education institutions (TEI) carried out 928 projects classified as innovative, under four Sectoral Operational Programmes, namely:
- Development in Human Resources (DHR),
- Increase in Enterprises' Competitiveness (IEC),
- Fish and
- Integrated Regional Development (IRD).

TEI did not carry out any projects under three remaining SOPs: Transport, Agriculture and Technical Assistance.

Most projects (583, i.e. 63%) were carried out by public TEI, while the remaining 345 (37%) by private ones (Table 2).

Under SOP Development in Human Resources (DHR), TEI carried out 317 innovative projects, of which 60% (190) were those carried out by non-public TEI (see Table 1). All these projects can be classified as soft projects, mostly aimed at creating new educational products, e.g. as many as 71 post graduate studies and 7 MBA programmes. Other educational products were different kinds of vocational trainings, language courses, new qualifications and skills and distant-learning courses in different fields. TEI also created such new products as labour market diagnoses, vocational consultancy, actions promoting equal chances in the labour market, etc. TEI did not carry out any other types of innovative projects (eg. process or organisational) under this SOP. It results from the programme framework and legal basis strictly defining what kind of projects can be carried out and co-financed, thus determining in a way also the scope of produced innovations. Applying European Commission's criteria of defining innovations, the outcomes of projects carried out under DHR can be classified as process-oriented innovations, because they are a development of new and/or improvement of already existing methods, instruments and approaches; as target-oriented innovations for they set up new objectives and approaches in order to identify new possibly successful qualifications and creating new jobs on the labour market and last but not least as context-oriented innovations, developing political and institutional structures in the labour market.

TEI realised 7% of the total number (4488) of projects under SOP DHR, and they absorbed 5% of total EU funding spent under this SOP. However there were significant differences between beneficiaries: the top five beneficiaries who carried out in all either the comparatively largest number of projects or projects of the highest costs are some of the best-known and renowned technological schools (polytechnics) and universities in the country, e.g. University of Bialystok 2 projects of the highest value (46.4 million PLN) in this group, next Wroclaw Technological School 6 projects which cost 21.2 million PLN and Warsaw University, which carried out 23 projects of the total cost of 18.3 million PLN,

Analysis of SOP Fish reveals that TEI carried out 29 projects, of which 25 can be classified as product innovations and 4 as marketing innovations. The first group mostly consists of new research, while the latter one includes four actions promoting fish consumption. All these projects were carried out by public TEI.

The share of TEI in total number (4128) of projects under SOP Fish equals barely 1%, but they absorbed 3% of total EU funding spent under this SOP. The cost range of projects realised under this SOP was between 140 thousand PLN for the research by Agricultural Academy in Szczecin (the minimal cost in this group) and 2.5 million for a project by Maritime Academy. Agricultural Academy in Szczecin was the main beneficiary in the discussed group, as it realised 21 projects for 18.8 million PLN, under SOP Fish.

According to the findings, SOP IEC was supportive to mostly public TEI (61 projects out of 62 total), as only one non-public TEI carried out a project under this programme. Most (47) projects were hard projects aimed at building, modernising or equipping laboratories. They are classified as organisational innovations as well as those soft ones (9) aimed at creating technology transfer networks. Only 9 projects in this group were product innovations providing foresight and improving quality of research.

The share of TEI in total number (15514) of projects under SOP IEC equals barely 0.4%, but they absorbed 3% of total EU funding spent under this SOP.

Table 1: Basic data for innovative projects by TEI.

Under SOP	Number of projects by TEI	Share of projects by TEI in total No of projects *in %*	Share of total EU funding absorbed by TEI *in %*
DHR	317	7	5
Fish	29	1	3
IEC	62	0,4	3
IRD	520	3,8	7

Source: author's elaboration.

TEI carried out most of their innovative projects (520 of 931 total) under SOP IRD. Public TEI realised 366 (70% out of 520 total) projects, while non-public TEI realised 154 (30%) projects. In total number, as many as 284 project were classified as organisational innovations, of which 123 were results of soft project implementing a wide range of novelties: strengthening cooperation with other institutions, knowledge transfer systems,

scholarhips for students, organising trainships, creating innovation networks, supporting innovation activities of students, etc., and 161 were effects of hard projects aimed at building new or modernising/ extending/ equipping already existing laboratories, research centres, digital libraries, ICT systems, music halls (Musical Academy), gallery (Academy of Arts), etc. The remaining 227 projects (44%) resulted in product innovations, very similar to those obtained under SOP DHR, those are: postgraduate studies, innovative research, trainings and vocational consultancy.

The share of TEI in total number (13597) of projects under SOP IRD equals 3.8%, and they absorbed 7% of total EU funding spent under this SOP. The biggest projects were carried out by public renowned TEI, e.g.: Politechnics of Gdansk (new building for the Faculty of Electrics and IT) 53 million PLN, University of Silesia (new building for the Faculty of Neophilology) 52 million PLN, Warsaw School of Economics (new building for teaching and research) 45.6 million PLN, Jagiellonian University in Cracow (Auditorium Maximum, second stage of construction) 45 million PLN.

Table 2: Classification of analysed projects according to Oslo Manual Criteria.

Under SO Programme	**Number of project carried out by tertiary education institutions:**		
	total	public	non-public
Development in Human Resources total	**317**	**127**	**190**
product innov.	317	127	190
Fish total	**29**	**29**	**0**
product innov.	25	25	0
marketing innov.	4	4	0
Increase in Enterprises' Competitiveness total	**62**	**61**	**1**
organisational innov.	9	9	0
product innov.	6	6	0
process innov.	47	46	1
Integrated Regional Development total	**520**	**366**	**154**
organisational innov.	123	112	11
product innov.	227	120	107
process innov.	161	131	30
other*	9	3	6
Total	**928**	**583**	**345**

*could not be classified due to insufficient description.
Source: author's elaboration.

The total value of analysed projects (see Table 3) equalled 2133721 thousand PLN, of which EU co-funding made 63% (1343719 thousand PLN). These values show considerable financial transfers over a relatively short, two-year time span, resulting in the increase of innovations at TEI, although it may be argued that the earlier analysed share of TEI in absorption of EU funds was rather insignificant: from barely 0.4% of total EU co-funding under SOP IEC up to 7% under SOP IRD.

Table 3: Financial effects of analysed projects.

Tertiary education institutions	Total value of projects *in thous. PLN*	Total EU funding *in thous. PLN*	*in %*
Non-public total	**383806**	**253829**	**66**
under SOP:			
DHR	198006	139132	70
Fish	0	0	0
IEC	366	270	74
IRD	185434	114427	62
Public total	**1749914**	**1089890**	**62**
under SOP:			
DHR	222689	154061	69
Fish	34539	25309	73
IEC	203553	135867	67
IRD	1289133	774653	60
All TEI total	**2133721**	**1343719**	**63**

Source: author's elaboration.

Still, the fact is that none of the past, analysed programmes or actions within were aimed at TEI as the only or main beneficiaries and innovations for education were not the main objective of any of them either.

That was also the first programming period, or rather a two-year part of it, when Poland could use EU funds. This required elaborating new procedures, carrying out evaluations (which in Poland were a new process itself), training both institutions implementing these programmes and prospect beneficiaries.

In these circumstances, the above presented results can be assessed as satisfactory.

SUPPORT FOR INNOVATIONS IN HIGHER EDUCATION IN POLAND OVER 2007-2013

The experience of the past programming period and still increasing urgency to support innovations in higher education in Poland resulted in elaborating and approving a special Sectoral Operational Programme Innovative Economy (IE) for 2007-2013.

The overall objective of SOP IE is to develop Polish economy based on innovative enterprises. This objective will be achieved through implementation of the following specific objectives:

i. Improvement of innovativeness of enterprises.
ii. Improvement of competitiveness of Polish science.
iii. Strengthening of the role of science in economic development.
iv. Increasing the share of innovative products of the Polish economy in the international market.
v. Creation of permanent and better workplaces.
vi. Growth of the use of information and communication technologies in the economy.

Scientific and research centres, including TEI, are listed as prospect beneficiaries of this programme, especially of Priority I 'Research and Development of Modern Technologies' and Priority II 'Infrastructure of R&D'. The Programme has been co-financed from resources of the European Union and the state budget. The allocation for the IE amounts in total to EUR 9,711,630 thousand including EUR 8,254,885 from the European Regional Development Fund.

This is the biggest so far implemented programme supporting innovation in all fields, including tertiary education and its institutions as beneficiaries. Although other on-going programmes support TEI in carrying out innovation projects as well. SOP Infrastructure and Environment offers support for TEI within Priority XIII titled 'Infrastructure of higher education'. Its objective is to develop modern universities and academies, especially those educating student in fields most desirable from the point of view of knowledge-based economy, i.e. mathematical, technical, natural and medical sciences.

Water Centre at Warsaw University of Life Sciences-SGGW – example of project under SOP Infrastructure and Environment 2007-2013

Scientific and Educational Centre of the Faculty of Civil and Environmental Engineering – so called "Water Centre" of the Warsaw University of Life Sciences is located at the main university campus in Warsaw, in Ursynow district, at the intersection of Nowoursynowska and Ciszewskiego Streets. The project takes the area of around 14600 m^2. It includes educational facility with the development area of 1954.8 m^2 and the total area of 5565.3 m^2, usable area of 4557.4 m^2 and cubage of 28167 m^3. In the building there are 19 laboratories equipped with the most modern scientific and research equipment. In Scientific and Educational Centre there are 19 laboratories: Water Monitoring Laboratory; Groundwater Flow Monitoring Laboratory; Water Quality Laboratory; Water Chemistry, Sewage Sediments, Soils and Plants Laboratory; Fluid Mechanics Laboratory; Sedimentation Laboratory, Irrigation and Drainage Laboratory; Laboratory of Water Ecosystems Ecology; Laboratory of Ecotechnology; Meteorological Data Control and Atmospheric Processes Modelling Laboratory; Physics of Porous Media Laboratory; Geoinformation Systems and Environmental Modelling Laboratory; Geoinformation and Geodesy Laboratory; Physical Properties of Soil and Rock Laboratory; Mechanical Characteristics of Soil and Rock Laboratory; Dynamics Characteristics of Soil and Rock Laboratory; Geosynthetics Testing Laboratory; Physical Processes in Construction Laboratory; Strength of Materials and Building Constructions Laboratory. They have 310 sets of modern scientific and research equipment and 51 computers together with specialist software and equipment.

In the building of the Scientific and Educational Centre, next to the laboratory rooms, there are exhibition rooms which present and popularise research fields of the modern water and sanitary engineering. The permanent and periodic exhibition is intended for secondary school students and visitors to Warsaw University of Life Sciences. Drinkable water source with artesian water from the Oligocene (Tertiary) and Pleistocene (Quaternary) water deposits as well as from urban waterworks (from surface water intakes) are one of the most distinguishing elements. They also enable conducting selected water quality research.

The educational establishment called Water Park is situated in the area surrounding Scientific and Educational Centre. It is a model of a watercourse connected with trophic reservoirs, with its outlet in the ultimate water reservoir. The whole water system represents water circulation in the environment. The system is divided into two parts; one which represents a mountain catchment basin and the other which represents lowland river catchment basin. The water system is fitted with models of hydrotechnical buildings, situated along the river course and on reservoirs (trap, tower spillway, weirs). The models present sample construction solutions for the hydrotechnical building industry and make it possible for the students and PhD researchers to acquaint themselves with modelling systems of hydraulic and hydrobiological conditions. In the reservoir, there is a dock ending with a glass wall and lighting, which allows to descend into the water reservoir and observe the development of the coastal area of the water region. Water in the system of Water Park flows in a closed circuit thanks to the system of pumps feeding water from the ultimate reservoir to the initial station - a ground object built in gabion and landmass construction. The quality of water is maintained mainly through a natural reed bed treatment plant which is a part of the water system.

The mentioned structure is the only in the country. It will be used in the educational process, to transfer general knowledge, to illustrate water circulation in nature and to teach principles of designing and carrying out hydrotechnical undertakings. A meteorological station will be situated in the surroundings of the Centre. It will monitor the quality of atmospheric air and selected meteorological parameters measured on multiple levels. The station will operate within the air monitoring network of the Voivodship Inspectorate for Environment Protection. Both the building and Water Park have been equipped with amenities meeting the educational and work needs of the disabled.

The main aim of the project is to improve the quality of education and research at the Faculty and to support economy through the transfer of knowledge, which necessary for creating knowledge-based society.

It is assumed that the project will result in increase in the number of students and PhD researchers, consequently in the number of researchers, scientists and specialists whose professions based on modern technologies and engineering are most crucial for economic development of the country.

Total cost of the project 52.7 million PLN, of which 41.95 million PLN of EU funds (79.6% of total cost).

The project began in 2008 and was completed in 2010.

CONCLUSIONS

The above presented findings based on analysis of innovative projects carried out by Polish TEI over 2004-2006(2009) programming period and outlines of support available under SOPs 2007-2013 confirm the important role that EU funding granted under selected operational programmes plays in supporting higher education in Poland.

The first programming period resulted in 928 projects carried out by TEI under four SOP which did not aim particularly at supporting such units. In this context the effects may be assessed as satisfactory. However analysis of the list of beneficiaries indicates that the biggest projects were realised by the biggest, best-known TEI who are situated in the largest cities of Poland. These TEI also appeared to be the most active in carrying out projects co-financed by EU, some of them carried out as many as 23 projects (e.g. Warsaw University) over one brief programming period of 2004-2006. Thus the allocation of funds among smaller TEI, especially those operating in areas distant from big cities, seems insufficient to support them in implementing innovations. The main problem of smaller TEI when applying for EU funds is the necessity to cover a part of costs of the project by the beneficiary. Thus, in the situation of shortage or lack of their own funds they realise either relatively smaller projects or none.

TEI realised a wide range of different projects, both those enhancing their educational and scientific facilities and infrastructure and those extending educational offer and research.

The new programming period 2007-2013 offers a new instrument – SOP IE - targeted in whole at improving and increasing innovativeness of Polish economy and tertiary education institutions meant as innovation engines paying a double role of creating innovations through research and creating innovative human capital through education process. Together with other SOPs, namely Infrastructure and Environment and Human Capital, they make so far optimal tools to achieve targets set up in EU and Polish policies and strategies promoting knowledge triangle.

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THE APPLICATION OF UNIVERSITY CLASSIFICATION FOR DEVELOPING HIGHER EDUCATION INSTITUTE PERFORMANCE INDICATORS

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ABSTRACT

This paper aims to demonstrate the Thailand Higher Education Classification Model (THEC-Model) based on research performance, and to compare the results of it with the university classification by the Office of the Higher Education Commission(OHEC) whereby universities can be classified as National Research Universities (NRUs).The classification, conducted by using empirical data and a statistical approach, was initiated to develop the THEC-model as a multi-dimensional classification and to link the classifications to rankings. The results of the hypothesis test showed that the criteria in four classification dimensions included; (1) Research funding, (2) Instructional programmes and curriculums, (3) Instructors and research staff body, (4) Student body. These criteria have influenced the research performance in three dimensions; (1) research output (2) citations, and (3) research awards. It was found that six universities were classified as NRUs, and this result is consistent with the classification by OHEC. The findings provide important information, for example, classification criteria, outstanding and disadvantageous criteria would enable the policy-makers to manage higher education effectively to elevate universities to become word-class, and increase competitiveness.

Keywords: Higher Education Classification; National Research University; Performance Indicators; Management in Education; Thailand University; global competitiveness

INTRODUCTION

Schwab (2009) stated that two fundamental factors are crucial to enhance long-term competitiveness and sustainable development. One is 'higher education and training' which is important to propel efficiency-driven economics. Another is 'innovation' which is necessary to drive the economy progressively. This is consistent with Schultz (1961); Lucas (1988);Becker (1993); Hedin *et al.*, (2005); Burke *et al.,*(2009); and Ramoniene and Lanskoronskis (2011) who stated that 'higher education and training'is vital to any country because firstly, it increases the value chain beyond simple production processes and products; secondly, it produces well-trained workers who are adaptable in changing environments; and lastly, it produces a healthy workforce which has the potential to improve national productivity and competitiveness. In addition, Romer (1990); Grossman and Helpman (1991); and Aghion and Howitt (1992) stated that the standard of living in the long run can be improved by innovation. Ramoniene and Lanskoronskis (2011) added that innovation could result from the higher education system. Similarly, innovation may not occur without high quality scientific research institutions, a highly

skilled workforce including scientists and engineers, and sufficient research and development (R&D) investment.

The situation mentioned above has led many countries and governments to recognize and drive 'research universities' as essential for improving competitiveness and bringing forth sustainability in countries (Liu and Cheng, 2005; and Deem *et al.*, 2008). Furthermore, Lee *et al.,* (2007) stated that organizational flexibility, long-term enterprise development, and a country's competitiveness depend primarily on graduates and university education. Consistent with the Commission on Higher Education or (CHE) under the Ministry of Education in Thailand[1], the Scopus International Database indicated that between 2004 and 2008 over 90% of research stemmed from universities, indicating that the university is the largest source of research and researchers in a country.

However, in Thailand, there are almost 200 public and private accredited universities. The number of universities has doubled over the past decade.This has resulted in greater diversity and more complexity in the higher education system. Four major factors[2] have impacted the higher education system, including (1) politics, for example, decentralization and local administration, (2) economics, for example, autonomous universities, and globalization, (3) society and demography, for example, a reduction in population, life-long learning, social networking, retirement, and lastly (4) technology, for example, e-learning. As a result, the question how to classify and evaluate the university as a "research university" is raised. Several researchers, for example, Amano and Chen (2004); McCormick and Zhao (2005); Liu and Liu (2005); Phusavat and Chansa-ngaveg (2007); Phusavat (2008); Bartelse and van Vught (2009); and Shin (2009), reported that higher education classification has become a crucial strategy to deal with diversity in the higher education system because it allows us to understand the nature and characteristics of HEIs under the same criteria and parameters. At the same time, a ranking system allows a HEI to reflect on estimated quality and recognition, especially in the research dimension.

Under the crucial role of the higher education system that has influenced competitiveness, the research question is how the HEIs should be classified on a research basis to improve research competency, which is fundamental to enhance global competitiveness. To answer the research question, this paper primarily aims to develop the THEC-Model based on research dimensions that are useful for classifying the research university.

BACKGROUND

This section describes the following three areas of the background. Firstly, HEI classification is analyzed in terms of the criteria and parameters used to classify the research university. Secondly, HEI ranking is employed to analyze the criteria and parameters used to evaluate the research dimension, and lastly, the NRU classification is used to compare the outcomes of the developed THEC- Model and the NRU classification by OHEC. The detail is shown below:

Higher education classification

According to Bailey (1994), classification is an organizing or grouping process where the same properties are grouped together. The Carnegie Foundation for the Advancement of Teaching (CFAT)[3]stated that HEI classification in educational terms is employed to recognize the similarities and differences for individual institutions under the required criteria and parameters. This is consistent with McCormick (2008) who stated that classification is more likely to identify the similarities and differences of HEIs than the ranking of HEIs.The result is that classification fails to reflect university quality and recognition, and only identifies the nature and characteristics of the university (Phusavat and Chansa-ngavej, 2007). HEI classification has been popular worldwide, particularly in the U.S.A. where CFAT has been in practice for over three decades. Subsequently, it has been used as a basic framework for HEI classification in many countries, for example, the Chinese HEIs by Liu and Liu (2005), the European HEIs by Bartelse and van Vught (2009), and Thailand's HEIs by Phusavat (2008). The detail of higher education classification is as follows:

The US Higher education classification system by CFAT

The US higher education classification system by CFAT[4] was initiated in 1973, and there have been many revisions since in 1976, 1976, 1994, 2000, 2005, and most recently in 2010, so that it could be employed consistently with changing situations and the greater complexity and diversity of U.S.A.'s HEIs. Changes have occurred in the labels used, definitions, and technical parts. However, the core HEI classification remains the same, based on the research and teaching objectives, the degrees offered, the number of comprehensive programs and size.

Research-based HEI classification demonstrated that all of the versions of the US higher education classification system focus on the research dimension. In the1976 version, the dimension based on research was categorized into C1 under the name "C1: Doctoral-Granting Institutions", and was subdivided into four subcategories (SC) including SC1: Research Universities I (implying that 50 or more doctoral degrees awarded and received annually $40 million or more in federal support.), SC2: Research Universities II (implying that 50 or more doctoral degrees awarded and received between $15 million and $40 million per year.), SC3: Doctoral-Granting Universities I (implying that at least 40 doctoral degrees annually awarded in five or more disciplines.); and SC4: Doctoral-Granting Universities II(implying that at least ten doctoral degrees awarded in three or more disciplines or 20 or more doctorates per year total). In the 1994 version, four subcategories were re-categorized into four major categories which highlighted the research dimension. The 2000 version, which also focused on the research dimension, was divided into two categories; C1: Doctoral/Research Universities Extensive (implying that 50 or more doctoral degrees per year awarded across at least 15 disciplines) andC2: Doctoral/Research Universities Intensive (implying that at least 10 doctoral degrees per year awarded across three or more disciplines, or at least 20 doctoral degrees per year overall).

A significant comprehensive overhaul[5] was the result of the 2005 version of the US higher education classification, namely, single classification was replaced by multiple classifications.

The previous single classification was updated and renamed “Basic Classification” which became a set of multiple classifications in the 2005 version. Not only the research dimension, but also a multi-measure research index was established. The research-focused area was categorized into C2 (Doctorate-Granting Universities) in ‘Basic Classification’, implying at least 20 research doctoral degrees awarded during the update year. In addition, C2 was subdivided into 3 subcategories (SC) including SC1: Very High Research Universities (RU/VH), SC2: High Research Universities (RU/H), and SC3: Doctoral/Research Universities (DRU). Research activity-based subcategories involved research & development (R&D) expenditure in science and engineering (S&E); R&D expenditure in non S&E fields; S&E research staff; doctoral conferrals in humanities fields, in social science fields, in STEM (science, technology, engineering, and mathematics) fields, and others (e.g., business, education, public policy, social work). Moreover, like the 2005 version, the 2010 version values the research dimension, and also gives significance to educational management under the ‘Community Engagement Classification’.

The Chinese higher education classification system

Liu (2007) and Ma (2004) stated that the HEI classification in China was of interest to the government, HEIs, and the academic community. The Chinese HEI classification was based on work by Shanghai Jiao Tong University (SJTU)[6] and by Liu and Liu (2005), both placing significance on the research dimension. The former is based on student profile, consisting of two categories; C1: universities with an engineering or technology orientation (implying that over one-third of all graduate students enrolled in engineering fields) and C2: universities with a medical orientation (implying that over one-third of all graduate students enrolled in medical fields) while the later, which is also based on the research dimension, was categorized into C1, which consisted of the following two subcategories; SC1: Research Universities I, and SC2: Research Universities II , where the criteria are the following; (1) Number of doctoral degrees in excess of 193. (2) Ratio between doctoral and baccalaureate degrees more than 0.09 for SC1 and between 0.06 and 0.09 for SC2 (3); the amount of government research funding over 44 million Yuan., and (4) the number of SCIE and SSCI articles per capita (at least 0.7).

European higher education classification system

Bartelse and van Vught (2009) stated that the establishment of the European higher education classification was to satisfy the five following stakeholders: students, HEIs, businesses and industries, policymakers, and researchers. It consisted of four phases: Phase 1 to develop the conceptual model and set dimensions and indicators; Phase 2 to test the classification model developed following phase 1; and Phase 3 and 4 to conduct analysis and fine-tuning which was in-process during phase 1 and was taken into consideration in this paper. Bartelse and van Vught (2009) grouped the HEIs into five categories and 14 dimensions. The research-focused group was categorized into C2: Research and Innovation, consisted of 2 dimensions with measurement criteria for each dimension as follows: D5: Research intensiveness has two criteria:(1) Number of peer reviewed publications per FTE academic staff and (2) The ISI based citation indicator, normalized per field, also known as the “crown indicator”. D6: Innovation intensiveness has four criteria: (1) Number of start-up firms, (2) Number of patent applications

filed, (3) Annual licensing income, and (4) Revenues from privately funded research contracts as a percentage of total research revenues.

Thailand's higher education classification

In 2006, the HEI classification was applied to Thailand HEIs by the Office for National Education Standards and Quality Assessment (ONESQA)[7], aiming to evaluate external quality assurance at the second round between 2006 and 2010 to see whether and how much HEI operation was executed consistently with the mission. Consequently, the HEI operations were carried out in accordance with the core HEI mission and were divided into four categories:(1) university focusing on graduate production and research, (2) university focusing on graduate production and social development, (3) university focusing on graduate production and art and cultural development, and (4) university focusing on graduate production only.

In 2008, the Ministry of Education divided the HEIs into four categories; including C1:community college, C2: baccalaureate colleges, C3: specialized institutions which consisted of two sub categories (SC) as follows: SC1 universities focusing on graduate degrees , and SC2 universities focusing on undergraduate degrees , and lastly C4: advanced research universities, and doctoral universities, resulting in the ONESQA changing higher educational classification in the light of the external quality assessment for the third round (2011-2015) in accordance with the Ministry of Education's announcement. However, C1 added two subcategories, including SC1 graduate production and research-based university, and SC2 graduate production and social development-based university.

The outcomes of HEI revision by the ONESQA showed that all versions of HEI classification have focused on the research dimension, but no specific criteria have been defined, just the broad scope is provided so that each institute can choose the HEI classification in accordance with its philosophy, goal, and mission. One more important issue is that HEI classification by ONESQA has followed the Framework of the Second 15-Year Long Range Plan on Higher Education in Thailand)[8](2008-2023), ONESQA's classification of research university and graduate university have been outlined with the following scope, (1) it focuses on research-based postgraduate programs, doctorate programs and post-doctorate programs, (2) it is located in the capital and cities, (3) 100% doctorate professionals (4) Science and Technology students and Social Sciences students ratio (90:10). This kind of university has a mission and role on national competitiveness; the graduates are expected to be global prime movers and cognitive leaders.

Higher education ranking system

Phusavat and Chansa-ngavej (2007) and Salmi and Saroyan (2007) stated that a ranking system was used to rank higher education institutions. The ranking reflected the quality and recognition of the HEIs, especially in the research activity dimension. These studies analyzed the common criteria that have been used in the international ranking system: SJTU[9]and Times Higher Education QS World Universities Ranking (THE-QS)[10], and quality assurance system for

higher education. Common criteria were found which comprise three parts; (1) publications in science-oriented indices, science and nature, social science oriented indices, and other indices, (2) citations include bibliometrics (counting publications and citations), highly cited publications, citations in engineering publications, citations in social science oriented indices , and research citation per head of academic faculty (3) research award, prestige, and patents issued including national research awards, international research awards, number of patents issued, alumni of institution winning Nobel prizes and fields medals, academics peer review, and employer reputation. The results are consistent with Bowden (2000); Dill and Soo (2004); van Dyke (2005); and Williams and van Dyke (2005).

NRU Classification by the OHEC

In 2009, the Royal Thai government (RTC) had an urgent policy urging that the OHEC develop the NRUs objectively, moving university development toward 'world-class universities', and public service universities which play important roles in problem-solving in the social and manufacturing sectors. Such a policy is consistent with the Framework of the Second 15-Year Long Rang Plan on Higher Education of Thailand) (2008-2023) formulated in 2008 by the OHEC[11]. Under this framework, the university is divided into four categories. The research dimension is assigned into C4: Research University and Graduate University.

The NRU eligibility criteria[12] consist of the following: firstly, it must be one of the top 500 universities ranked by THE-QS in 2008, whose ranking criteria are based on four pillars: (1) research quality, (2) teaching quality, (3) student employability, and (4) international outlook. Research quality was measured by two indicators: an academic "peer review", and the number of research citations per head of academic faculty. Teaching quality was measured in terms of student-teacher ratio. Student employability and the international outlook were measured by two indicators, international teacher and researcher ratio, and the proportion of international students. To qualify, a university has to have demonstrated any of following work results, (1) Scopus articles of no less than 500 publications in the last five years (2004-2008), (2) distinctly international researches at least 2 of 5 THE-QS fields; Arts & Humanities, Social Sciences, Technology, Life Sciences & Biomedicine, Natural Sciences; , and (3) more than 40% of overall instructors are doctorate professionals. Secondly, there must be a clear direction and uniqueness of a NRU, and lastly, there must be quality, accuracy, and modernity in the university.

NRUs selection criteria[13] shall be based on a development plan, an operational plan, and a budget plan to move a university (1) to become 1 of 400 universities that has never been ranked before, or to improve the ranking to be among the previous 400 universities for an overall rank and field rank, (2) to establish a national and international research center that is linked to industry, or is consistent with the national strategy, (3) to hold an international conference in expertise fields, increasing the number of students and foreign instructors, and the availability of international programs.

Many people of various backgrounds such as administrators, staff, and research fellows of HEIs have a strong interest in this project and hope that their own institution will be selected as a NRU. There are nine universities classified as NRUs. They include Chulalongkorn, Kasetsart, Mahidol, Khon Kaen, Chiang Mai, Thammasat, Suranaree University of Technology, King Mongkut's University of Technology Thonburi, and Prince of Songkla University. However, academics, researchers, students, and many people in various occupations discuss and criticize the method, criteria, and the results for selecting NRUs and the role of NRUs.

METHODOLOGY

To achieve the research objectives, processes have been set which are divided into three phases (see Figure1).

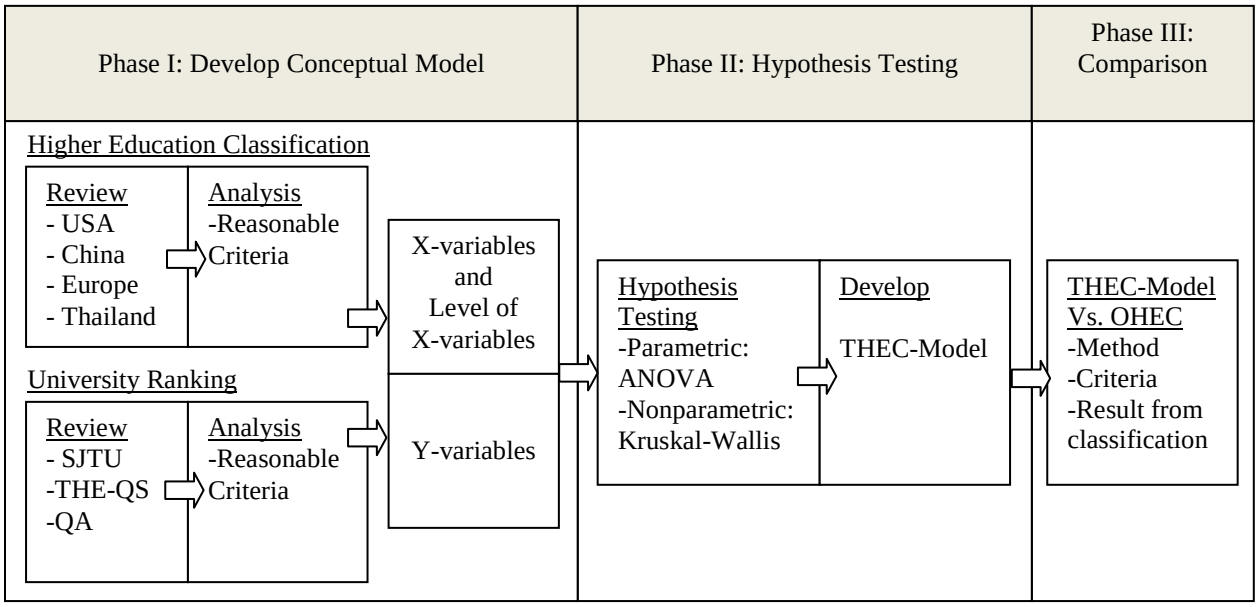

Figure 1: The Three phases of the methodology framework.

Phase 1: develop conceptual model

The methodology consisted of the following three steps. The first step is to review the classifications in such locations as the US, China, Europe, and Thailand to analyze the dimensions, criteria, and specific conditions of categories as input or 'X-variables' which would be used to perform the hypothesis test at Phase 2. The second step is to review the international rankings: SJTU and THE-QS educational quality assurance criteria to identify the evaluation criteria for research dimension as output or'Y-variables' to further perform the hypothesis test at phase 2. The third step defines 'X-variables', level of 'X-variables' and 'Y-variables' that are appropriate for Thailand's higher education context.

Phase 2: hypothesis testing

Phase 2 consisted of the two following steps. The first step was to conduct a hypothesis test to analyze whether or not the 'X-variables' have significant impact on 'Y-variables'. That is to say, the hypothesis test was designed to see which criteria could be applied to classify higher education significantly. A total of 50 independent samples were used, consisting of twenty-three public universities, and twenty-seven private universities, to test the hypothesis where the database was derived from the OHEC and ONESQA (June 1, 2009- May 31, 2010). The detailed hypothesis test consisted of the three following steps; (1) to test the relationship among Y-variables; Y_1, Y_2, and Y_3 by using 'Pearson's correlation coefficient. (2) to test the assumptions for 'Parametric', including two tests 'Normality Test' to determine if y-values for each population have a normal distribution. The 'Shapiro-Wilk'was employed to test the assumption under null hypothesis or H_0: the population is normal and the alternative hypothesis or H_a: the population is non-normal (see detail in, D' Agostino and Stephens, 1986 and Shapiro and Francia, 1972). Another kind of hypothesis test that was used was 'Homogeneity of Variance' to determine if y-values for each population have equal variances. The 'Levene's tests' was used to perform the hypothesis test under H_0: equal variances versus H_a: not all variances being equal. (3) 'Parametric' or 'Nonparametric' statistics were used for the hypothesis test. For this step, the assumption results for 'Parametric' were as follows; if H_0 was accepted for two tests, the 'Parametric' would be used through 'Analysis of Variance or ANOVA' under H_0: all population is equal, and H_a: at least one is different from the others (see detail in Johnson and Wichern, 2008). On the contrary, if H_0 was rejected only one test, the'Nonparametric'would be used through 'Kruskal-Wallis' under H_0: all of the population medians are equal and H_a: at least one of the medians is different from the others (see detail in Gibbons, 1976).The second step was to develop the THEC-Model; the results of 'ANOVA' or 'Kruskal-Wallis' in the case of rejecting H_0 at alpha.05 would be used to develop the THEC-Model.

Phase 3: comparison the classification results

Phase three compares the classification results for NRUs by using the THEC-Model and OHEC in the year 2009 based on the viewpoint of method, criteria, and classification results particularly in the category of 'Research-Intensive Universities'.

RESULTS

This section represents the results for each respective phase with the following detail:

Phase 1: develop conceptual model

The outcome of the review and analysis of the higher education classification showed six dimensions as follows: D1 Research funding, D2 Instructional programmes and curriculums, D3 Instructors and research staff body, D4 Student body, D5 Size, Location, and campuses, and D6 University-industry collaboration in research. The criteria of each dimension/X- variable and the specific conditions of categories/levels of X- variables were selected for Thailand HEI classification. In addition, the review of the international ranking SJTU and THE-QS, and criteria for higher education quality assurance based on the context of research activity evaluation as outputs or Y-variables found that the following three dimensions were common to assessments; D1research output, D2 citations, D3 research awards. A Y-variable in each dimension was selected for Thailand's HEI evaluation based on the research dimensions as follows:'Y_1' refers to the percentage of research and innovations published or registered as intellectual property or patented or utilized at the national or international level in proportion to the number of full-time faculty, 'Y_2' refers to the percentage of research articles cited in the refereed journals or national or international databases in proportion to the number of full-time faculties, and Y_3 refers to the percentage of full-time faculties who have received academic or professional awards at the national and international level, in D1, D2, and D3 respectively (see the Table 1).

Table1: The X-variables and the Y-variables to test the hypothesis.

Dimensions (D)	Criteria or X-variables	Specific Conditions of Categories (C) or levels of X-variables	No. of Hypo.		
			Y_1	Y_2	Y_3
D1 Research funding	X_1 The amount of internal and external grants for research and innovations in proportion to the number of full-time faculty (FTF)	C1 ≤ 80,000 Baht C2 80,000-180,000 Baht C3 ≥ 180,000 Baht	H1	H21	H41
D2 Instructional programmes and curriculums	X_2 Medical programmes	C1 Universities have no medical programme C2 Universities have medical programme	H2	H22	H42
	X_3 Engineering programmes	C1 Universities have not engineering programme C2 Universities have engineering programme	H3	H23	H43
	X_4 The percentage of graduate programmes in proportion to total programmes	C1 ≤ 30% C2 30-50% C3 ≥ 50%	H4	H24	H44
	X_5 The percentage of doctoral programmes in proportion to total programmes	C1 ≤ 10% C2 10-15% C3 ≥ 15%	H5	H25	H45
	X_6 The percentage of doctoral programmes in proportion to bachelor programmes	C1 ≤ 30% C2 30-50% C3 ≥ 50%	H6	H26	H46
D3 Instructors and research staff body	X_7 Number of FTFs and research staff	C1 ≤ 400 people C2 400-1,000 people C3 ≥ 1,000 people	H7	H27	H47
	X_8 Number of FTFs who are qualified as thesis advisors	C1 ≤ 200 people C2 200-500 people C3 ≥ 500people	H8	H28	H48
	X_9 The proportion of the number of faculty members holding bachelor, master and doctoral degrees or equivalent to the number of FTF	C1 (1) doctoral degrees 1-29% or (2) doctoral degrees 30-49% but bachelor degrees >5% C2 (1) doctoral degrees 30-49% and bachelor degrees < 5% or (2) doctoral degrees ≥ 50% and bachelor degrees >10% C3 (1) doctoral degrees ≥ 50% and bachelor degrees ≤ 5%	H9	H29	H49
	X_{10} The proportion of the number of faculty members holding doctoral degrees or equivalent to the number of FTF	C1 ≤ 30% C2 30-50% C3 ≥ 50%	H10	H30	H50
	X_{11} The proportion of the number of faculty members holding the position of instructor, assistant professor, associate professor, and professor to the number of FTF	C1 (1) A combination of Asst Prof., Assoc Prof., and Prof. 1-29% or (2) A combination of Asst Prof., Assoc Prof., and Prof. 30-49% but Assoc Prof. combine with Prof. <30% C2 (1)A combination of Asst Prof., Assoc Prof., and Prof. 30-49% and (2) Assoc Prof. combined with Prof. >20% or (1) A combination of Asst Prof., Assoc Prof., and Prof. ≥ 50% and (2) Assoc Prof. combined with Prof. <20% C3 A combination of Asst Prof., Assoc Prof., and Prof. ≥ 50% and (2) Assoc Prof. combined with Prof. ≥ 20%	H11	H31	H51
	X_{12} The proportion of the number of faculty members holding the position of associate professor and professor to the number of FTF	C1 ≤ 5% C2 5-15% C3 ≥ 15%	H12	H32	H52
	X_{13} The number of faculty members holding the position of professor	C1 ≤ 10 instructors C2 10-20 instructors C3 ≥ 20 instructors	H13	H33	H53
	X_{14} The percentage of FTFs who actually function as thesis advisors in proportion to the number of those who are qualified	C1 ≤ 70% C2 70-80% C3 ≥ 80%	H14	H34	H54
D4 Student body	X_{15} Number of full-time equivalent students or FTES.	C1 ≤ 10,000 students C2 10,000-20,000 students C3 ≥ 20,000 students	H15	H35	H55

	X_{16} The percentage of graduate students in proportion to the number of total students	**C1 ≤ 10% C2 10-20% C3 ≥ 20%**	**H16**	**H36**	**H56**

Table1: Cont.

Dimensions (D)	Criteria or X-variables	Specific Conditions of Categories (C) or levels of X-variables	No. of Hypo.		
			Y_1	Y_2	Y_3
D5 Size, Location, and campuses	**X_{17} The proportion of the number of full-time equivalent students to the number of full-time faculties and research staff.**	**C1 ≤ 20 C2 20-25 C3 ≥ 25**	**H17**	**H37**	**H57**
	X_{18} Location and campuses	**C1 City location/one campus C2 Suburban or rural location/one campus C3 City location/multiple campus C4 Suburban or rural location/ multiple campus**	**H18**	**H38**	**H58**
D6 University-industry collaboration in research	**X_{19} The percentage of FTF who are involved in providing academic services as consultants, thesis committee members outside the institution, academic or professional committees at the national or international level in proportion to the number of FTF.**	**C1 ≤ 40% C2 40-60% C3 ≥ 60%**	**H19**	**H39**	**H59**
	X_{20} The percentage of academic and professional service activities/projects responding to the needs for development and strengthening the society, community, nation and the international community in proportion to the number of FTF.	**C1 ≤ 40% C2 40-60% C3 ≥ 60%**	**H20**	**H40**	**H60**

Phase 2: hypothesis testing

To be consistent with the methodology, this section presents the results of phase 2 with an explanation which consists of the following two steps. The first step shows results from a hypothesis test where the detail consists of the three following steps; (1) The results of the relationship test for Y variables. (2) The results of parametric assumption tests and (3) The results of 'ANOVA' or 'Kruskal-Wallis' test. The second step show results from developing the THEC-model. The detail is shown below:

The results from the first step: test hypothesis

(1) The results from the relationship test

A relationship test for each pair of Y variables, $Y_1 - Y_2$, $Y_1 - Y_3$, and $Y_2 - Y_3$ was performed using Pearson's correlation coefficient, the results indicate r_{12}=.607, p-value = .001, r_{13}=.446, p-value = .002, and r_{23}= .655, p-value=.001, respectively. Because all p-values were smaller than .01, it is evident that the correlation was not zero for alpha.01. However, to determine what the extent of the relations for each pair of Y variables was by means of the percentage of the variance accounted for R^2, it indicated R^2 = 36.84 for r_{12}, representing the relationship by 36.84% (account for 36.84%), r_{13}, R^2 = 19.89, representing the relationship by 19.89%, (account for only 19.89%), and r_{23}, R^2 = 42.90, representing the relationship by 42.90%. In this paper, the hypothesis test selected the independent Y variables Y_1, Y_2andY_3 for analysis. The result was that the hypothesis test for X variables (X-variables; X_1-X_{20}) and Y-variables (Y_1, Y_2,andY_3) was

independent, respectively. A total of 60 hypotheses included H_1-$H_{20}$for eachX variable (X-variables; X_1-X_{20})and Y_1, H_{21}-H_{40} for eachX variable (X-variables; X_1-X_{20}) and Y_2, and H_{41}-H_{60} foreachX variable(X-variables; X_1-X_{20}) andY_3(see Table 1).

(2) The results form test assumption of 'Parametric'

The test assumptions for 'parametric' were performed to test 'Normality' with the 'Shapiro-Wilk Test', and test 'Homogeneity of Variance' by using Levene's test. It was found that only 3 of 60 hypotheses could apply the 'parametric' conditions including, H14 (hypothesis test betweenX_{14} andY_1), H37 (hypothesis test betweenX_{17} and Y_2), and H54 (hypothesis test betweenX_{14} andY_3) while the other remaining hypothesis applied the 'Nonparametric' for further analysis in the third step.

(3) The results from 'ANOVA' or 'Kruskal-Wallis' test

The 'ANOVA' or 'Kruskal-Wallis' test was employed to determine which hypothesis has differences between the categories or level of each X-variable and has significantly statistically influenced the differences in each Y-variable at alpha.05 (see Table 2).

The results showed that (1) the H1-H20 for each X variable (X-variables; X_1-X_{20}) and Y_1 showed that 7 of 20 hypotheses; H1, H6, H9, H10, H12, H16 , and H20, or 5 dimensions and 7 X-variables (D1 consisted ofX_1, D2 consisted of X_6, D3 consisted of X_9, X_{10}, X_{12}, D4 consisted of X_{16}, and D6 consisted of X_{20}) where H_0 was rejected because these hypotheses provided a p-value <.05, it was interpreted that the level or categories of these variables resulted in the differences in Y_1 variables. In respect of H21-H40, the test between X-variables; (X_{21}-X_{40}) and Y_2 indicated 8 of 20 hypotheses, including H21, H24, H25, H26, H29, H30, H32 ,and H36, or 4 dimensions with 8 X-variables (D1 consisted ofX_1, D2 consisted ofX_4, X_5, and X_6, D3 consisted ofX_9, X_{10}, X_{12}, and D4 consisted ofX_{16}, where $H_0$was rejected because these hypotheses provided a p-value <.05, it was interpreted that the level or categories of these variables resulted in the differences in Y_2 variables. In respect of H41-H60, the test between X-variables; X_{41}-X_{60}) and Y_3 indicated 18 of 20 hypotheses, where H_0 was rejected because these hypotheses provided p-value <.05, it was interpreted that the level or categories of these variables resulted in the differences in Y_3 variables.

In the step H1, for example D1 Research funding consisted of X_1 where X_1 referred to the amount of internal and external grants for research and innovations in proportion to the number of FTF, consisted of three categories (C1 ≤ 80,000 Baht, C2 80,000-180,000 Baht, and C3 ≥ 180,000 Baht) (see data in Table 1). With 'Kruskal-Wallis', the hypothesis results showed p-value =.014 where H_0 was rejected at alpha.05, indicating that the level or categories of X_1 variable resulted in the differences in Y_1 variable (see data in Table 2). Other hypotheses could be explained in the same way.

The results from the second step: Develop the THEC-Model

To classify the HEIs as 'research universities', the last category for each X variable (in Table 1) was applied. For example, X_1 consisted of C1, C2 and C3 respectively, and then C3 was taken into consideration for classifying 'research universities'. This paper demonstrates both 'single dimensions' and 'multiple-dimensions' for research university classification. This was to allow diversification under the interesting criteria at statistical significance at alpha .05. In the case of a 'single dimension', each dimension was taken into consideration for each hypothesis. For example, for D1 in H1, a different classification was found under X_1 criteria which resulted in differences in Y_1criteria. When the results of these 'single dimensions' were taken into consideration, there were 11 research universities classified as follows: Chulalongkorn, Kasetsart, Khon Kaen, Chiang Mai, King Mongkut's University of Technology Thonburi, Suranaree University of Technology, Thammasat, Mahidol, Prince of Songkla University, King Mongkut's Institute of Technology North Bangkok, National Institute of Development Administration (see detail in Figure 2).

Table2: The results from hypothesis testing in the case of reject null hypothesis.

D	X-variables	Categories (C)	Y_1			Y_2			Y_3		
			No. of Hypo.	(N)	P-value	No. of Hypo.	(N)	P-value	No. of Hypo.	(N)	P-value
D1	X_1	C1	H1	27	0.014[K]	H21	7	0.009[K]	H41	25	0.000[K]
		C2		12			9			10	
		C3		11			11			11	
D2	X_2	C1							H42	30	0.007[K]
		C2								14	
	X_3	C1							H43	13	0.009[K]
		C2								31	
	X_4	C1					4			15	
		C2				H24	9	0.005[K]	H44	11	0.000[K]
		C3					14			17	
	X_5	C1					6			12	
		C2				H25	7	0.018[K]	H45	11	0.000[K]
		C3					13			13	
	X_6	C1	H6	23	0.030[K]	H26	10	0.009[K]	H46	20	0.009[K]
		C2		12			7			11	
		C3		11			9			11	
D3	X_7	C1							H47	21	0.026[K]
		C2								13	
		C3								12	
	X_9	C1	H9	29	0.015[K]	H29	8	0.003[K]	H49	27	0.000[K]
		C2		10			8			8	
		C3		11			11			11	
	X_{10}	C1	H10	25	0.016[K]	H30	6	0.004[K]	H50	24	0.000[K]
		C2		14			10			11	
		C3		11			11			11	
	X_{11}	C1							H51	34	0.012[K]
		C2								5	
		C3								7	
	X_{12}	C1	H12	19	0.030[K]	H32	6	0.004[K]	H52	15	0.000[K]
		C2		17			8			16	
		C3		13			13			14	
	X_{13}	C1							H53	34	0.006[K]
		C2								5	
		C3								7	
	X_{14}	C1							H54	7	0.011[A]

		C2								6	
		C3								7	
D4	X_{15}	C1								21	
		C2							H55	11	0.004 [K]
		C3								12	
	X_{16}	C1		22			6			21	
		C2	H16	13	0.019 [K]	H36	12	0.015 [K]	H56	11	0.001 [K]
		C3		8			7			8	
D5	X_{17}	C1								12	
		C2							H57	11	0.045 [K]
		C3								21	
	X_{19}	C1								22	
		C2							H59	16	0.021 [K]
		C3								6	
D6	X_{20}	C1		11						10	
		C2	H20	20	0.020 [K]				H60	18	0.001 [K]
		C3		17						16	

Y	Y1							Y2								Y3																		TOTAL
Dimensions(D)	D1	D2	D3			D4	D6	D1	D2			D3			D4	D1	D2					D3							D4			D5		D6	
X-variables	X1	X6	X9	X10	X12	X16	X20	X1	X4	X5	X6	X9	X10	X12	X16	X1	X2	X3	X4	X5	X6	X7	X9	X10	X11	X12	X13	X14	X15	X16	X17	X19	X20	
No. of Hypo. (H)	H1	H6	H9	H10	H12	H16	H20	H21	H24	H25	H26	H29	H30	H32	H36	H41	H42	H43	H44	H45	H46	H47	H49	H50	H51	H52	H53	H54	H55	H56	H57	H59	H60	
Chiang Mai University: CMU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	32
Mahidol University: MAHIDOL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	32
Chulalongkorn University: CU	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X			29
Kasetsart University: KU	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X		X		28
Khon Kaen University: KKU	X	X	X	X	X			X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X		X		X			26
King Mongkut's University of Technology Thonburi: KMUTT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X		X				X	X		X	26
National Institute of Development Administration : NIDA	X	N	X	X	X	X	X	X	X	X	N	X	X	X	X	X			X	X	N		X	X	X	X				X		X	X	26
Suranaree University of Technology: SUT	X	X	X	X	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X		X		X					X	24
Thammasat University:TU	X		X	X	X		X	X	X			X	X	X		X	X	X	X			X	X	X		X	X		X				X	21
Shinawatra University: SIU		X			X		X		X	X	X	X	X	X					X	X	X		X	X		X		X		X		X		18
Prince of Songkla University: PSU	X				X		X	X	X					X		X	X	X	X			X				X	X	X	X		X		X	17
Srinakharinwirot University: SWU			X	X		X						X	X		X		X	X				X	X	X						X	X			13
Assumption University: AU		X					X		X	X	X							X	X	X	X	X									X		X	12
King Mongkut's Institute of Technology Ladkrabang: KMITL					X		X		X					X				X	X							X	X			X			X	10
King Mongkut's Institute of Technology North Bangkok: KMUTNB	X						X	X		X						X		X		X													X	8
Walailak University: WU							X			X							X	X		X												X	X	7
Rangsit University: RSU							X										X	X				X									X	X	X	7
Naresuan University: NU							X										X	X				X							X				X	6
Dhurakij Pundit University: DPU		X	X	X														X	X		X													6
Asia-Pacific International University APIU					X		X							X												X					X		X	6
Silpakorn University: SU									X									X	X										X			X		5
Mahanakorn University of Technology: MUT							X											X									X			X		X	5
Ubon Ratchathani University: UBU										X							X	X		X														4
Christian University: CHRISTIAN		X																	X		X									X				4
Burapha University: BUU																	X	X											X					3
Bangkok University: BU																		X				X							X					3
Stamford International University: STAMFORD						X																								X	X			3
Kasem Bundit University: KBU																		X													X			2
Chaopraya University: CPU																									X	X								2
Saint John's University: STJOHN																		X													X			2
Vongchavalitkul University: VU																		X													X			2
Siam University: SIAM																		X														X		2
Huachiew Chalermprakiet University: HCU																	X													X			2
Thaksin University: TSU							X																											1
Mae Fah Luang University: MFU																			X															1
Pathumthani University: PTU																		X																1
Payap University: PAYAP																															X			1
North Eastern University: NEU																		X																1
Sripatum University: SPU																		X																1
University of the Thai Chamber of Commerce: UTCC																		X																1
South East Asia University: SAU																		X																1
The Far Eastern University: FEU																															X			1
Yonok University: YONOK																															X			1
TOTAL	11	12	11	11	13	8	17	11	14	13	10	11	11	13	7	11	14	31	17	13	12	12	11	11	7	14	7	7	12	8	21	6	16	

Figure 2: The results of research university classification by THEC-model.

Note. 1 NIDA has only graduate students, so criteria of X_6 in D2 were not taken in consideration.

On the other hand, if 'multi-dimensions' (two or more dimensions) were taken into consideration, for example, a combination for dimension 1 in H1 (test between level or categories of X_1 and criteria of Y_1), along with dimension 4 in H16 (test between level or categories of X_{16} andY_1criteria) as shown in Figure 2, indicating that 'multi-dimension' for such pairs under combined criteria, it would include six research universities, including Chulalongkorn University, Kasetsart, Chiang Mai, King Mongkut's University of Technology Thonburi, Mahidol, and National Institute of Development Administration. Similarly, research university classification could be possible under the combination of other dimensions.

However, regarding the THEC- model development for classifying the research-intensive universities to produce potential personnel in different disciplines that meet the needs of the community, industry, and innovation development, leading to competitiveness for NRUs, this paper presented the development of the THEC-model based on 'multiple-dimensions', employing a combination of criteria for each X variable that has influenced the differences in all Y-variables, namely Y_1, Y_2, and Y_3. Such combinations showed that with 5 X-variables in 4 dimensions, namely; X_1 inD1, X_6 in D2, X_9, X_{10}, andX_{12} inD3 and X_6 inD4, there were a total 6 universities classified as research-intensive universities including Chulalongkorn, Kasetsart, Chiang Mai, King Mongkut's University of Technology Thonburi, Mahidol, and National Institute of Development Administration (see Table 3). The results were then compared to the NRUs classification by OHEC in phase 3.

Phase 3: comparison the classification results

This section presented the results of comparison for classification between the developed THEC-model and OHEC-based NRU classification. The comparison was made in three areas; method used, criteria used, and national research universities (NRUs) as described in Table 4.

DISCUSSION

The THEC-model, which is based on research dimensions, was developed to classify the research universities and NRUs in Thailand. The HEI classification conducted by using empirical data and a statistical approach was initiated to develop the THEC-model as a multi-dimensional classification and linked the classifications to rankings. Phusavat (2008) stated that Thailand's higher education system has been growing rapidly while the HEI classification in previous versions was based on a single dimension, and connects with quality assurance insufficiently and ineffectively. This is consistent with McCormick (2007) who added that in 2005 the HEI classification by CFAT changed from a single classification to multiple classifications.

Thailand's HEI classification has been of interest since 2006 when ONESQA classified the HEIs to evaluate external quality (2006-2010). However, each institution was allowed to choose the categories in a way that was consistent with its own goal, philosophy, and mission. Thus, to classify HEIs by using the THEC-model provides HEI administrators and policymakers with important and useful information to compare the classification results with the institution-

selected classification, and to analyze the strengths and weaknesses of the developed HEIs, and to benchmark with other HEIs in the group.

Table 3: The results of national research university classification by THEC-model.

Y	Y_1							Y_2							Y_3			
Dimensions (D)	D1	D2		D3		D4	D1	D2		D3		D4	D1	D2		D3		D4
X-variables	X1	X6	X9	X10	X12	X16	X1	X6	X9	X10	X12	X16	X1	X6	X9	X10	X12	X16
No. of Hypo. (H)	H1	H6	H9	H10	H12	H16	H1	H6	H9	H10	H12	H16	H1	H6	H9	H10	H12	H16
Chiang Mai University: CMU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mahidol University: MAHIDOL	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chulalongkorn University: CU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kasetsart University: KU	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
King Mongkut's University of Technology Thonburi: KMUTT	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
National Institute of Development Administration : NIDA	X	N	X	X	X	X	X	N	X	X	X	X	X	N	X	X	X	X
Khon Kaen University: KKU	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	
Suranaree University of Technology: SUT	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X	
Thammasat University:TU	X		X	X	X		X		X	X	X		X		X	X	X	
Shinawatra University: SIU		X			X			X	X	X	X			X	X	X	X	
Srinakharinwirot University: SWU			X	X		X			X	X		X			X	X		X
Prince of Songkla University: PSU	X				X		X				X		X				X	
Dhurakij Pundit University: DPU		X	X	X										X				
Assumption University: AU		X						X						X				
King Mongkut's Institute of Technology Ladkrabang: KMITL					X						X						X	
King Mongkut's Institute of Technology North Bangkok: KMUTNB	X						X						X					
Asia-Pacific International University APIU					X						X						X	
Christian University: CHRISTIAN		X												X				
Stamford International University: STAMFORD						X												X
Chaopraya University: CPU																	X	
TOTAL	11	12	11	11	13	8	11	10	11	11	13	7	11	12	11	11	14	8

The outcome of NRU-focused HEI classification by using the THEC-model appeared to be similar to that of the OHEC classification. It included the following five universities - Chulalongkorn, Kasetsart, Mahidol, Chiang Mai, and King Mongkut's University. Only one, the National Institute of Development Administration, was classified as "NRU" by the THEC-model, but it was not classified as "NRU" by OHEC. Furthermore, four institutions were not classified as "NRU" by the THEC-model, but they were classified as "NRU" by OHEC, they included Khon Kaen, Thammasat, Suranaree University of Technology, and Prince of Songkla University.

Table 4: Comparison of the developed THEC-model and the OHEC-based NRU classification.

Issues	Classify NRUs by THEC-model	ClassifyNRUsby OHEC
Method	The THEC-model used statistical principles with a hypothesis test to determine which levels of X-variables have significantly statistically influenced the differences in Y-variables. It was constructed in multi-dimensions. It linked the classification with ranking and educational quality assurance.	NRUs classification[14] by OHEC selected the HEIs with requirement; namely being ranked as Top 500 of THE-QS Ranking. On contrary, it was out of the Top 500 of THE-QS Ranking, it's required to demonstrate the research publications for at least 500 articles publicized in the international journals within 5 years (2004-2008), and outstanding national research for at least 2 of 5 fields of THE-QS and 40% of its academic staff must have doctoral qualifications.
Criteria	The criteria used to classify the NRUs in the context of 'multi-dimension' which was caused by the combination of X-variable criteria that have influenced the difference in 3 Y-variables; Y_1, Y_2, and Y_3. - Criteria of X-variables, as follows: D1 Research funding; $X_1$the amount of internal and external grants for research and innovations in proportion to the number of FTF. D2Instructional programmes and curriculums; X_6 the percentage of doctoral programmes in proportion to bachelor programmes. D3 Instructors and research staff body; X_9 the proportion of the number of faculty members holding bachelor, master and doctoral degrees or equivalent to the number of FTF X_{10} the proportion of the number of faculty members holding doctoral degrees or equivalent to the number of FTF, and X_{12} the proportion of the number of faculty members holding the position of associate professor and professor to the number of FTF D4 Students body; X_{16} the percentage of graduate students in proportion to the number of total students -Criteria of Y-variables, as follows: D1Research output; Y_1 the percentage of research and innovations published or registered as intellectual property or patented or utilized at the national or international level in proportion to the number of FTF D2 Citations; Y_2 the percentage of research articles cited in refereed journals or national or international databases in proportion to the number of FTF D3 Research awards; Y_3 the percentage of FTF who received academic or professional awards at the national and international levels.	The NRUs selection criteria[15] applied the THE-QS ranking which contemplated the published researches in the Scopus database and indicators representing Thailand context. The criteria used included as follow: D1Research Quality; (1) number of published international publications, (2) number of published publications to number of FTF, (3) number of corresponding authors to number of total publications, (4) number of patents earned domestically and internationally, (5) experts' opinion, for examples Club Professor, (6) research identity (Targeted Niche, e.g. identity), D2 Teaching Quality; (1) The proportion of the number of FTES to the number of FTF, (2) number of faculty holding doctoral degrees, (3) number of professors, (4) graduated to total FTES ratio. D3 International Outlook; (1) number of foreign students, (2) FTF to foreign researcher ratio, (3) Joint research with corresponding authors in Thai people, D4 Graduate's employability and satisfaction (1) satisfaction evaluated by employer, (2) Public private partnership (PPP).
No. of universities	6 universities including Chulalongkorn, Kasetsart, Mahidol, Chiang Mai,King Mongkut's University, and National Institute of Development Administration	9 universities includingChulalongkorn, Kasetsart, Mahidol, Khon Kaen, Chiang Mai, Thammasat, Suranaree University of Technology, King Mongkut's University of Technology Thonburi, and Prince of Songkla University.

In regard of the criteria, it was found that (1) Khon Kaen and Suranaree University of Technology failed to meet only one requirement for D4 Students' body in criteria. X_{16} refers to the percentage of graduate students in proportion to the total number of students, accounting

for 19.29% and 11.22%, respectively. But Khon Kaen University was close to the THEC-model criteria (20%); (2) Thammasat did not meet the requirement for two criteria, the criteria X_{16}, accounted for 19.86%, close to the target 20% for NRUs and D2 in criteria X6, which refers to the percentage of doctoral programmes in proportion to bachelor programmes, accounting for 24.74%, which is some way off the THEC-model criteria (≥ 50%), (3) Prince of Songkla University did not meet the requirement for four criteria. Of the four, two criteria were similar to that of Thammasat; X_6 and X_{16}or 44.01% and 12.48%, respectively, and other two criteria - D3 Instructors and research staff body consisted of X_9 which refers to the proportion of the number of faculty members holding bachelor, master and doctoral degrees or equivalent to the number of FTF, accounted for 48.89% for doctoral degree and 5.63% for bachelor degree, close to the THEC-model criteria (see in Table1), and X_{10} refers to the proportion of the number of faculty members holding doctoral degrees or equivalent to the number of FTF accounted for 48. 89%, close to the THEC-model criteria (≥ 50%). In conclusion, the THEC-model and OHEC results were consistent.

However, to classify HEIs by using empirical data under a statistical approach, which was initiated to develop the THEC-model, limitations on information and data were found. For example, only 50 of 200 universities (one fourth of HEIs in Thailand) were selected. Some criteria were incomplete or had insufficient data, so they failed in the'parametric' conditions. In this case, the'nonparametric' test was used, resulted in less accuracy. Importantly, the HEIs had no common data set, for example, national and international publications were not separated, resulting in restrictions in selecting the hypothesis test criteria.

IMPLICATIONS

The developed classification model benefits academic researchers, HEI administrators, and policy-makers for many reasons. Firstly, it meets the academic researcher's need for information in the classification system to determine the important variables for HEI explanation in different areas. For example, Shin and Milton (2006) analyzed the variables connected to tuition. Henderson and Buchanan (2008) analyzed the variables pertaining to faculty teaching and research. Burke *et al.* (2005) analyzed the faculty salaries. Secondly, the information obtained from HEI classification enables higher education administrators to deal with the strengths and weaknesses in terms of educational quality, and allow them to understand the position of the institution and develop the strategy to maintain their position or elevate it to a better position. Thirdly, since the THEC-model criteria were generated by reviewing the classification system in different locations, such criteria could be applied extensively at domestic and international level. Fourthly, the policymakers understand the information reflecting the reality of individual HEIs, especially in the research dimension. For example, they can know which NRUs are distinctive or disadvantaged in any area. This enables them to manage higher education in the right direction and move the HEIs toward world class universities. Lastly, the developed THEC- model is based on a statistical approach and empirical data improved the reliability and would be beneficial to the CHEs in Thailand for further improvement on research-focused HEI classification criteria in the future.

FUTURE STUDIES

Future work should take the following areas into consideration: firstly, improvement of common data set to enable more effective HEI classification; secondly, to standardize the figures on educational management in each section to allocate resources better, especially in the NRUs; thirdly, it should investigate the strategies for reposition, for example, from research universities to NRUs by using SWOT Analysis to understand the strengths and weaknesses of the institution, and opportunities and threats in environmental, political, economic, social, demographic, and technological contexts. Finally, it should designate the combination sets in other types in pursuit of the desired classification objectives, for example, developing a research-based model, and further examining the weight for each dimension.

CONCLUSIONS

The THEC-model was designed to classify Thailand's HEIs, focusing on 'research universities', particularly, NRUs. The THEC-model development stemmed from linking the classification criteria where nature and characteristics of HEIs are identified, with the ranking criteria based on research performance that reflects the HEI's quality and recognition. The classification criteria were generated by reviewing the existing popular classification systems in different locations such as the US, China, Europe, and Thailand. On the other hand, the ranking criteria were developed by reviewing the criteria used in SJTU, THE-QS, and educational quality assurance. Criteria were derived from both reviewing the classification and ranking systems, and were aligned consistently with the higher educational context in Thailand.

HEI classification consists of the following six dimensions (1) research funding, (2) instructional programmes and curriculums, (3) instructors and research staff body, (4) student body, (5) size, location, and campuses, and (6) university-industry collaboration in research. The HEI Ranking consists of three following dimensions (1) research output (2) citation, and (3) research awards. Such criteria have been statistically used for hypothesis testing and categorization. The criteria affecting the research performance, and the results of hypothesis tests will then be applied to classify HEIs in multiple dimensions, namely, the criteria affecting the research performance in three dimensions were taken into consideration.

As a result, the HEI classification criteria for NRU consisted of four dimensions (out of 6 dimensions), including (1) research funding, (2) instructional programmes and curriculums, (3) instructors and research staff body, (4) student body. Such classification criteria showed that six universities were classified as NRUs, including Chulalongkorn, Kasetsart, Mahidol, Chiang Mai, King Mongkut's University, and National Institute of Development Administration. The results were consistent with NRUs classification by OHEC. The findings provide useful information for policymakers to develop plans and deal with the higher education system corresponding to the mission and excellence for individual institutions, especially in enhancing the HEIs to research universities, NRUs, and world-class universities. Universities are important sources of well-educated workers and a source of innovation, Schultz (1961); Lucas (1988); Becker (1993); and Hedin *et al.*, (2005); Burke *et al.,*(2009); Schwab (2009) and Ramoniene and Lanskoronskis

(2011),who are important for the business sector to propel enterprise development in terms of global competitiveness enhancement.

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NOTES

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EFFICIENCY AND EFFECTIVENESS OF PUBLIC SPENDING ON HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

European higher education systems are facing numerous changes and are becoming increasingly internationalised, deregulated, liberalised and market-oriented, which has its advantages and disadvantages, proponents and opponents. These trends have, among other things, resulted in an increasing financial autonomy of higher education institutions (HEIs) in the member states of the EU. However, the recent economic downturn has revealed numerous weaknesses of mechanisms of higher education (HE) funding.

This paper presents key characteristics of HE funding in the member states of the EU. In particular, it focuses on the characteristics and effectiveness of Slovenian higher education where an emphasis is given to HE funding and resources managed by HEIs.

The purpose of the paper is to show how complicated it is to search for the answer to the question of rational use of (public) funding in (Slovenian) higher education. There is no simple and unambiguous answer to the question of whether public funding in higher education is being used rationally. The aim of every member state of the EU is to provide the necessary conditions for effective and efficient higher education which provides equal opportunities, quality education and adequate employment opportunities for graduates, as well as supports the sustainable development of the society, country (and the EU). Therefore, HEIs, governments and other actors must be aware of their roles in the "knowledge society", and take responsibility for ensuring the expected economic, social and cultural prosperity.

Keywords: effectiveness, efficiency, public funding, higher education, Slovenia

INTRODUCTION

In the EU, higher education (HE) is a **public responsibility and public good** with high expectations of higher education institutions (HEIs) which are required to respond to societal needs and fulfil their three main missions: teaching, research and the transfer or exchange of knowledge (EPC, 2010) by:

- creating and maintaining an advanced knowledge base, and encouraging research and innovation,
- transferring knowledge to students to prepare them for their career and active citizenship in a democratic society, and to promote their personal development,

- and through the social dimension involving the impact of research and knowledge creation and diffusion on society at large, as well as equity in access independent of the socio-economic background.

The development of HE in EU countries in the past decade is an interesting subject for research, because of the numerous changes it has undergone. Among major factors that consequently influenced the behaviour and development of HE(Is) we can state:
- Bologna process: introduction of new HE structure (bologna three cycles),
- changes in funding of HEIs for teaching,
- demography and changes in the student body,
- development of private HEIs,
- establishment of (national) agencies for quality assurance in HE together with international ones ENQA and EQAR.

In 2009 Leuven Communiqué, the Bologna Process highlighted that **HE funding** had a direct impact on HE, and made it its priority with the need for new methods and instruments of HE funding and for a bigger diversity of funding sources.

When thinking about the future of HE, also global situation and trends in HE and other areas that influence the policy making must be taken into account. Among the major international events or trends influencing HE in the EU are:
- growing demand for HE and increase in % of generation that enters tertiary education,
- new learning technologies that put under reconsideration traditional course structure,
- internationalization of HE and development of transnational HE,
- global recession and financial crisis in 2008.

The efficiency of the use of HE funding has become very important due to the development of the HE system in recent years, an increasing number of people participating in it and consequently growing financial needs on the one hand, and limited public funding on the other. This issue was addressed in Study on the efficiency and effectiveness of public spending on tertiary education (St Aubyn et al., 2009). The study analysed the relationship between productivity, employability and expenditure on education, since the efficient use of resources depends on the effectiveness of the relationship between these elements. While some countries are efficient according to all the criteria (the UK, the Netherlands), the countries characterised by lower efficiency are countries of Southern and Eastern Europe unexpectedly, Italy, France, Germany, and also public HE in the USA.

In its Communication Europe 2020, A Strategy for Smart, Sustainable and Inclusive Growth, of 3 March 2010 (Europe 2020), the European Commission proposed to the EU members states to include among their national targets a goal of increasing the share of the population aged 30-34 with completed tertiary education from the current 31% to at least 40% by 2020. In Slovenia, in 2005 the share of this population was 25%, compared to 31% in 2008. Since public and private funds are very limited, this objective can only be achieved through their **careful allocation** and **efficient use**.

European HE systems are facing numerous changes and are becoming increasingly internationalised, deregulated, liberalised and market-oriented, which has its advantages

and disadvantages, proponents and opponents. These trends have, among other things, resulted in an increasing financial autonomy of HEIs in the member states of the EU. However, the recent economic downturn has revealed numerous weaknesses of mechanisms of HE funding.

In recent years, HEIs in Slovenia have been given considerable financial autonomy due to the transition to lump sum funding of study activities in 2004. HEI's increased institutional and financial autonomy gives them greater flexibility in managing resources (financial and others) which should result in a more efficient use of public funds. However, it requires from the recipients of funds **more knowledge and responsibility** when spending the funds received.

This paper deals with **efficient** use of public funds in HE (education) at the national level and in the relation state – HEI, it being understood that HEIs are part of the HE system and in pursuit of common national goals, and that at the national level efficient use of resources in HE, i.e. achieving the optimal ratio between the inputs and effects, must be considered together with the **effectiveness** of achieving the objectives and results for which the funds were intended.

DEFINITIONS AND TRENDS

Efficient and effective use of public funds

In accordance with the principle of efficiency, efficient use of public funds is achieved through the optimal ratio between the inputs and effects. Effectiveness, on the other hand, is measured by comparing specific objectives and planned outcomes, and refers to the achieving of the objectives and results for which the funds were intended.

This topic is especially demanding because of the differences in understanding the concepts of efficiency, economy, effectiveness and sound management in public and private sector.

The Rules on the Guidelines for a Coordinated Functioning of the System of Internal Control of Public Finance (Official Gazette of the RS, 2002) determine that sound management is at the same time economical, efficient and effective. Therefore, sound financial management includes (Guidelines for Auditing Sound Financial Management, 2006):

- the principle of efficiency, concerned with the optimal relationship between resources used and results achieved (in a similar manner as in economics),
- the principle of economy which requires that the resources used by organisations for the pursuit of their activities are made available at the right time, in appropriate quantity and quality and at the best price, and
- the principle of effectiveness which refers to attaining set objectives and achieving the anticipated results.

Sound financial management is achieved when organisations are economical, efficient and effective at the same time, i.e. a process or programme which is assumed to be economical with regard to invested resources, efficient with regard to their use and management and which successfully attains the anticipated results, is described as sound or that it brings

good value for money. These definitions are taken from the Council Regulation (2002), applicable to the general budget of the European Communities.

With HE policy measures, states can encourage or inhibit the efficiency and effectiveness of HEIs. Efficiency refers to the management of limited resources through the efficient work with students and achieving the best quality of studies given the financial limitations, as well as to the relevance of study programmes offered by HEIs. The latter refers especially to the connection with potential employers of HE graduates.

Financial challenges and HE reforms

In recent years, we have observed numerous reforms and changes in the European HE area. European HE systems are becoming increasingly market-oriented, deregulated, liberalised and privatised (OECD, 2008). The extent of reforms varies between countries, but none of them avoided them. These reforms have many common characteristics (Eurydice, 2008; Kaiser, 2002; Strehl, 2006; CEGES, 2007; Lepori, 2007; EUA, 2008):

- A share of GDP devoted to HE (and related social transfers), and the growth in expenditure on HE (at least until the 2009 economic crisis).
- Due to the limited public funding, the share of private funding is increasing.
- There is a general trend towards an increased autonomy in public funds spending and an increased accountability within HEIs.
- Increasing efforts for efficiency and effectiveness (also of public and private funds spending).
- Efforts to introduce and use the full-cost method in carrying out HE activities.
- Funding in terms of coordinating the available resources with national priorities, and guiding the development of HE and achieving national HE objectives through the systems and mechanisms of HE funding.
- A move towards a greater transparency and simplicity of funding, through the systems and mechanisms of funding – from the historical component and input, to the achievements or output of education and.
- the cost of education should not be covered by a single actor or the state.

As noted in the EUA's report University Autonomy in Europe I (Estermann and Nokkala, 2009), funding of study activities of tertiary education institutions in Europe is characterised by the following trends:

- Allocation of public funds by using the method of lump sum funding which is often based on the results or their target values.
- In most European countries, universities can collect tuition fees from at least part of the student population. However, there are differences in the methods of determining tuition fees and what expenses they should cover.
- In most countries, universities are still restricted in their operation in financial markets. Money borrowing is quite common, while investments are often possible only through "satellites" of legal persons established by universities.
- There are also significant differences in the ownership of property, where formal ownership does not necessarily mean the right of free disposal.
- In most countries, universities have the autonomy in human resource management (recruitment/dismissal), but they are usually limited when it comes to determining

wages, since their employees are civil servants or national frameworks exist within which their wages must be determined.

These and other trends reflect the problems regarding HE funding at the EU level which have also been emphasized by the European University Association (EUA) in its report (EUA, 2008). According to the EUA, due to the increasing costs of HE activities, the primary question of universities in the 21st century concerns the risks related to the sustainability of their mission.

With the above and other aspects of HE reform, society faces the challenge of ensuring more efficient study and research, referring to:

- the shortening of the length of study – in the EU, full-time undergraduate studies on average take 6 years (Key Data on Higher Education, 2007); in Slovenia, academic higher education studies on average take 6.9 years and professional higher education studies 5.9 years (Euroštudent, 2007),
- a more rational use of financial resources for study and research activities.

Despite the anticipation that the economic recession and financial crisis will increase the problems of insufficient public funding of HE by further reducing public expenditure on HE (Varghese, 2010), it is interesting that the OECD in second research which was carried out over the summer of 2010 and in which 25 OECD member states participated at the time of economic recovery and fiscal consolidation, shows that education systems have not been dramatically affected by the overall budgetary costs, and governments seem to be rather successful in protecting education spending, some of them by increasing social measures to contain education costs. (Damme, 2010) Rather opposing are the results of the EUA's continuous monitoring of the effect of the economic crisis on funding and its trends which show that European HE systems have been affected very differently and at different stages of the crisis. HEIs in most countries report being faced with uncertainty and expect further – and possibly deeper – cuts to come in the year following 2010. (Estermann, 2011)

National mechanisms for funding HE and HE policy

Funding mechanisms vary between countries. There are four mechanisms for allocating public funds to tertiary education institutions: negotiation, growth/supplement, a formula and a contract.

It is becoming increasingly obvious that countries do not sufficiently connect their funding mechanisms and HE policy, which significantly contributes to the inefficiency and ineffectiveness of public (and private) expenditure on HE. Furthermore, in such case, HEIs are not motivated and stimulated enough to actively monitor their economic and social environment and trends, and to consolidate their position as key economic and social factors.

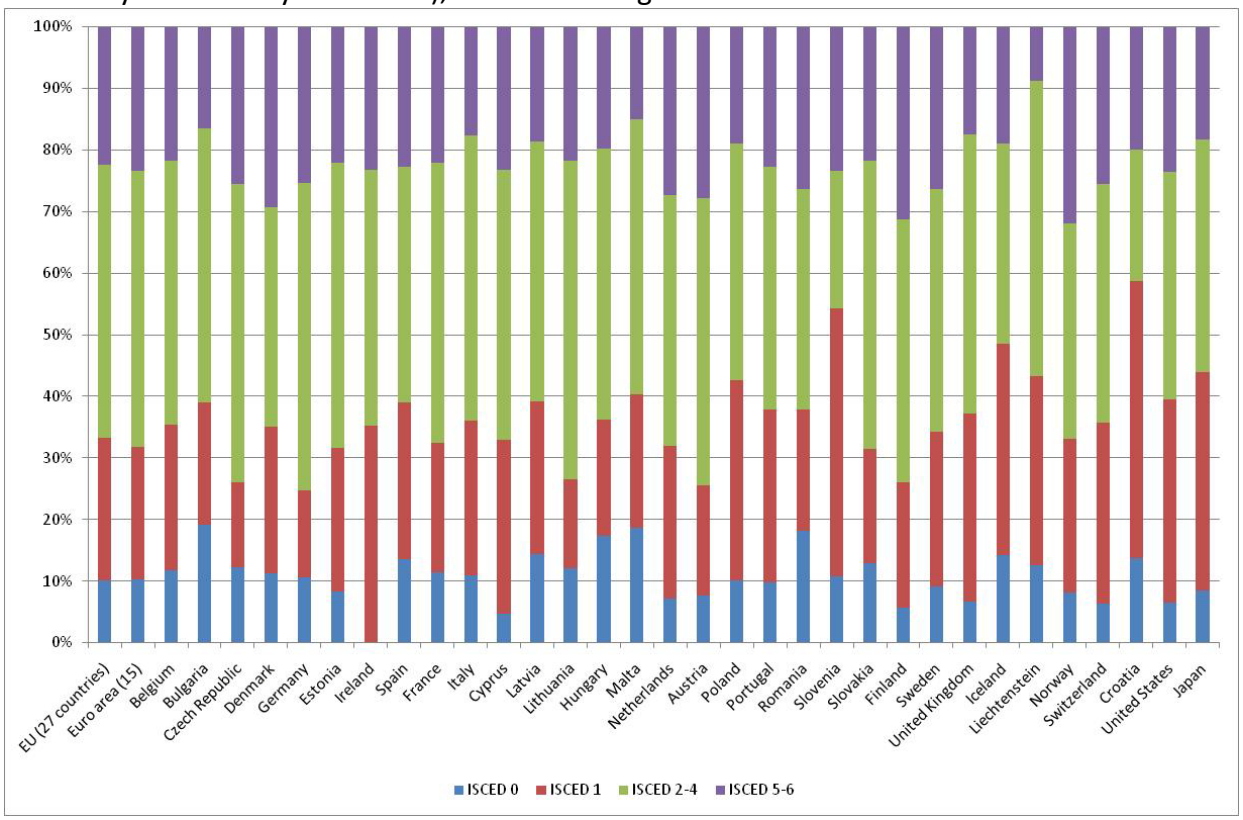
When defining systems of HE funding, at least the following goals of HE policy should be pursued:

- to achieve a greater responsiveness of HEIs to the needs of society (social and economic),

- to ensure a transparent and rational use of (budgetary) resources,
- to ensure quality HE, accessible to everybody, so that each student has the opportunity to start and complete their studies regardless of their social and economic status.

Public funds for education - international comparison

When examining the efficiency of using public funds in HE, we should look at how much budgetary resources is allocated to each segment of education (preschool, primary, secondary and tertiary education), as shown in Figure 1.



Remark: ISCED 0: pre-primary level and not allocated, ISCED 1: primary level, ISCED 2-4: secondary level, ISCED 5-6: tertiary level

Figure 1: Structure of public expenditure on education by levels of education in 2007 (Eurostat, 2011)

As demonstrated in Figure 1, the biggest relative share of total public expenditure on education in Slovenia is allocated to primary education (43.5%) and the smallest to secondary education (22%), which is almost the opposite of the EU average. Tertiary education in Slovenia is allocated just over 23% of public funds for education, which is slightly higher than the EU average and comparable to the average of the euro area.

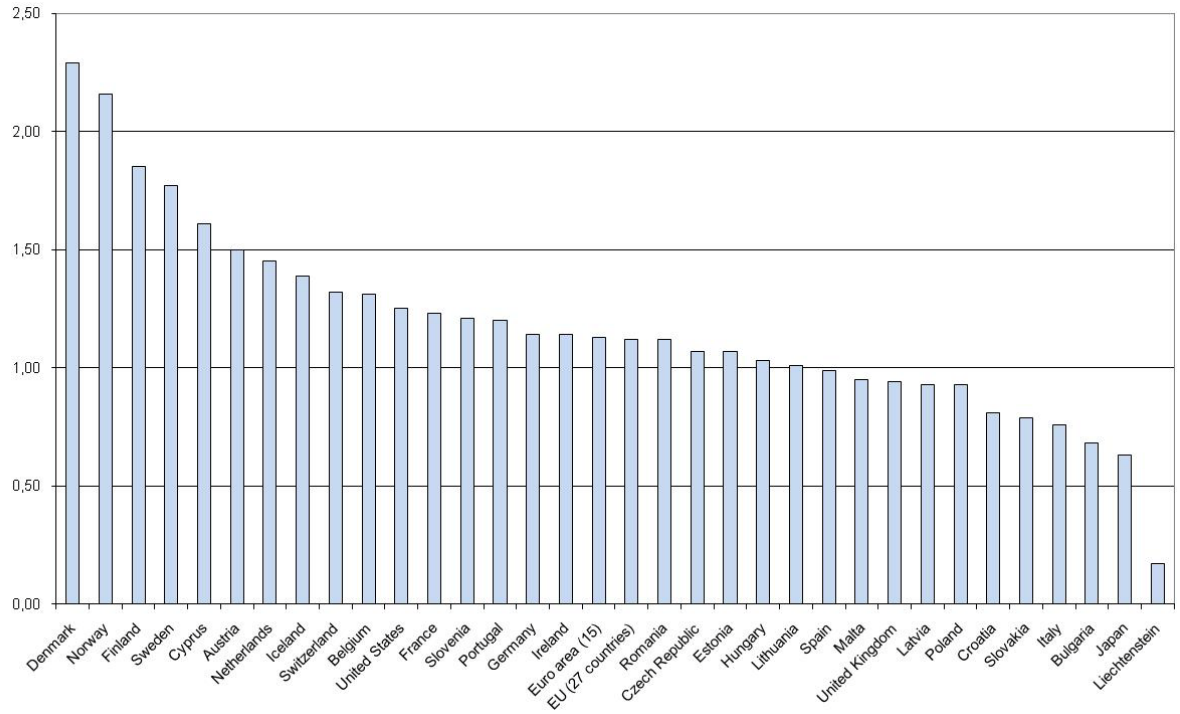


Figure 2: Expenditure on tertiary education as % of GDP in 2007 (Eurostat, 12 April 2011)

The Lisbon Strategy has set a target for countries to allocate 2% of their GDP to HE (public and private sources) by 2010. The target share of GDP from public sources has been met by the majority of EU member states, the EU 27 average being 1.12%. With 1.21% of GDP allocated to tertiary education from public sources, Slovenia is above the EU average (Eurostat, 2007).

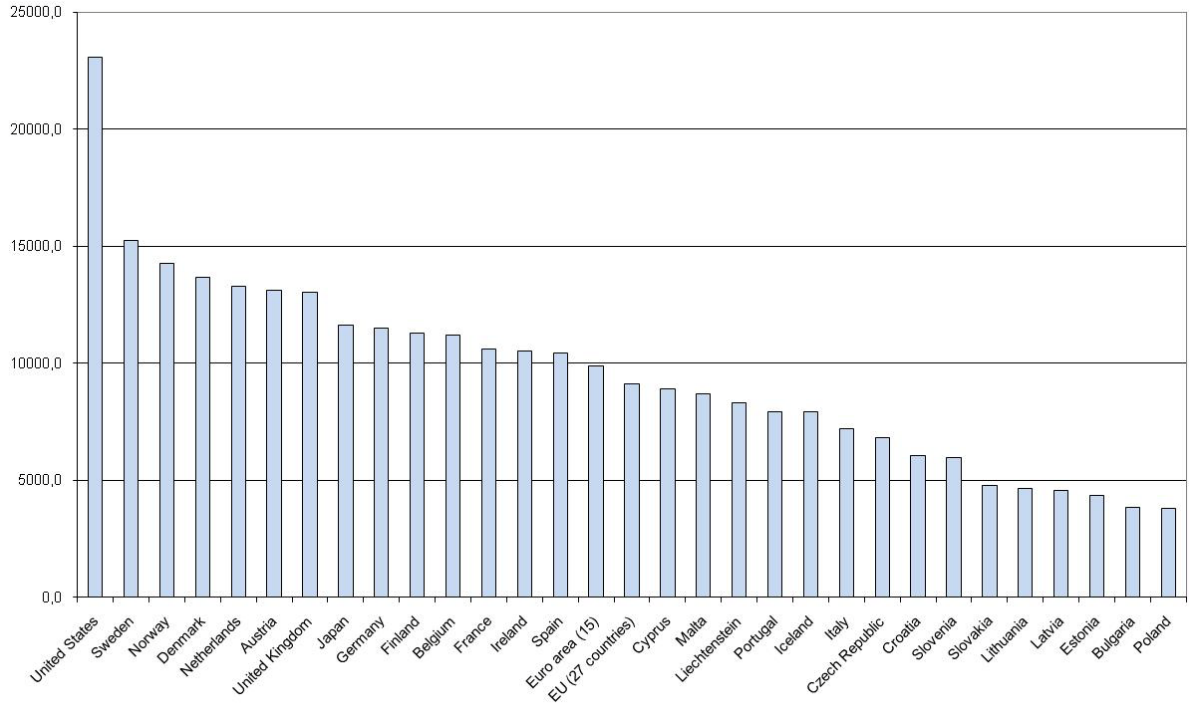


Figure 3: Expenditure on public and private tertiary educational institutions in PPS[1] per student in 2007 (Eurostat, 12 April 2011)

According to the share of GDP allocated to tertiary education, Slovenia is above the EU average, as shown in Figure 2, while according to the expenditure per student (even if expressed in PPS), it is at the tail of the EU member states. This is to some extent due to a high level of enrolment of the population in studies and the inefficiency of studies, i.e. students study considerably long and often do not complete their studies (approx. 35%, compared to the OECD average of approx. 30%) (OECD, 2009).

Measuring the efficiency and effectiveness in higher education

Until recently, the main performance indicator of the functioning of the HE system was the share of GDP allocated to HE by the state and the number of people enrolled in HE, rather than results of education and research and their impact on society. The 2008 global economic crisis, which resulted in drastic budget cuts, highlighted the issue of the efficiency of investments in HE. Measuring the effectiveness of HE and the efficiency of public spending is increasingly putting at the forefront monitoring of HE results, and is looking for the ways of measuring its impact on society. The Europe 2020 strategy (ET 2020) expects the EU member states to ensure at their national levels the efficiency of investments in educational systems, improve the outcomes of education, enhance the openness of educational systems (including a better matching of the outcomes of education and the needs of the market), and improve the transition of young people to the labour market. One of the five key indicators for measuring progress by 2020 is the increase of the share of the population aged 30-34 with completed tertiary education from the current 31% to at least 40%.

In a crisis, states must allocate their resources to the mechanisms that will contribute to the development of the economy, creation of added value and GDP growth. Since investments in education return only in the long run, they might be underestimated in short-term measures. This is highlighted in the OECD study with a suggestive title The High Cost of Low Educational Performance (OECD, 2010) which compares PISA results with the economic growth. The study found that even a relatively small improvement of the knowledge and skills of the workforce could have a significant impact on the future welfare of society, a key factor being the quality rather than length of education.

The study St. Aubyn et al. (2009) analysed cost-efficiency of HE systems using data envelopment analysis (DEA) and stochastic frontier analysis (SFA). In conclusions the study emphasized inefficiency in spending as an important issue when it comes to public tertiary education. An important group of countries was found to be operating under inefficiency conditions irrespective of the methods used (South and Eastern European countries, France, Germany, Italy, US public tertiary education), while on the other hand countries like the UK and the Netherlands appeared at the top of the efficiency ranking irrespective of the method or models used. As an important factor related to efficiency of TE was identified the

[1] PPS – Purchasing Power Standard.

quality of secondary education (using PISA results) and factors pertain to HEIs features, namely:

- The funding rules followed in each country. When funding to institutions depends more on outputs (e.g., graduations and publications) and less on historical attributions or inputs, efficiency tends to increase.
- Evaluation systems. Efficiency tends to be higher in countries where institutions are publicly evaluated by stakeholders and/or independent agencies.
- Staff policy. Institutions' autonomy to hire and dismiss academic staff and to set their wages is correlated with higher efficiency.

The study on progress in higher education reform across Europe (Jongbloed et al., 2010) identified four mechanisms used by EU states to encourage efficiency and cost reductions through targeted funding to HEIs over the period 1995–2008:

- Encourage mergers and amalgamations of institutions,
- Encourage reduction in the time students take to complete a degree,
- Encourage an increase in student success rates (i.e. reducing drop outs),
- Reward institutions that bring funding from the private sector.

Targeted funding in identified cases was allocated on the basis of:

- Competition (tendering) between HEIs,
- Negotiations between the government and (a selected number of) HEIs,
- Equal allocation of funding across HEIs.

The study then tried to measure HE systems performance of its key activities (teaching, research and knowledge transfer) through eight dimensions with selected indicators shown in Table 1.

Table 1: Performance dimensions and indicators.

Performance dimensions	**Indicators**
1. Access	Net participation rate
2. Mature learners	Mature (> 30 years old) enrolment rate
3. Graduation	Share of population with tertiary degree
4. Employability	Relative graduate earnings
	Graduate employment
5. Research output	Scientific articles
6. Capacity to attract funding	HE R&D income from business;
	Private (households') expenditure on HE
7. International student mobility	Incoming EU+ students
	Outgoing EU+ students
8. Cost effectiveness	Expenditure per student in Euro

Observed 33 HE systems of EU countries were divided into four groups on basis of the values of indicators in reference years 2002 and 2006:

- 'moving further ahead' – countries that are doing well in 2006 and that have further improved over the period 2002-2006,
- 'losing momentum' – countries that are still doing well in 2006 but have improved less over the period 2002-2006 then the average for the 33 HE systems,

- 'catching up' – countries that have improved more than other countries in period 2002-2006, but are still performing below average,
- 'falling further behind' – countries that in 2006 are performing below average and that over the period 2002-2006 have shown a change that is less than the average for the 33 HE systems.

The comparable analysis of performance of HE systems was done with the use of the performance quadrants (for case of Slovenia see Figure 5).

In 2010 European Commission, Economic Policy Committee published a working document on Efficiency and effectiveness of public expenditure on tertiary education in the EU in which approaches the tertiary education governance, efficiency and effectiveness observing the three missions of HEIs: teaching, research and the transfer or exchange of knowledge as interactive activities. An efficient and effective HE system should perform well in all three fields.

The document touches the open subject that HE is neglecting teaching in favour of research, while also recognizing that research and teaching are mutually sustaining. This study also identified as important elements for efficient HE: HEIs autonomy to select students, their financial autonomy and staff policy autonomy.

MEASURING THE EFFICIENCY AND EFFECTIVENESS OF SLOVENIAN HE

Overview of HE in Slovenia

As on 30 June 2010, the register of HEIs included (Marjetič and Dobnikar, 2010):
- 86 HEIs; of these 5 universities (with a total of 51 faculties, 2 professional colleges and 3 academies) and 30 single HEIs (15 faculties and 15 professional colleges), and
- 663 study programmes (48% undergraduate – first-cycle, 40% master – second-cycle and 12% doctoral study programmes), 84% of which were offered by public HEIs.

In 2009/10, as on 31 December 2009 (Statistical Office of the Republic of Slovenia), 114,873 students or 5.6% of the population were enrolled in tertiary education, of whom 98,279 in HE. In 2006/07, Slovenia had the highest share of the population aged 20-24 enrolled in tertiary education (46.1%; the EU27 average was 28.4%), i.e. 56.5% of the population of women and 36.3% of the population of men.

In 2009/10, 74% of HE students were enrolled in full-time study programmes, 92.4% (67,410) of them in undergraduate and 5.9% (4,289) in master (second-cycle) study programmes. 19.2% (14,061) of full-time undergraduate students were absolvents.

In 2009, there were 18,103 tertiary education graduates, 5% more than the previous year and 72% more than a decade ago. The average length of study in undergraduate study programmes in 2008 was 6.3 years, i.e. 6.8 years for academic and 5.9 years for professional higher education programmes (Komljenovič and Marjetič, 2010).

HE funding in Slovenia

In Slovenia, HE funding consists of the funding of HEIs and financial assistance offered to students who are considered part of the household in which they are financially supported by their family. Students who are not employed or registered at the Employment Service as active job seekers are, regardless of whether they are enrolled in full-time or part-time education, entitled to compulsory health insurance through their parents and may receive a child allowance up to the age of 26. Other transfers which aim to bridge socio-economic differences between individuals and thereby increase the accessibility of studies include state grants and subventions for food, transport as well as accommodation in student residence halls and private accommodation. Students can also apply for Zois scholarship (for talented students) and sponsorships by future employers.

In addition to public expenditure on educational institutions (346.6 million EUR in 2008), public expenditure on tertiary education also includes transfers to households and other private entities which represent almost a quarter (23%) of total public expenditure on tertiary education (104.8 million EUR in 2008).

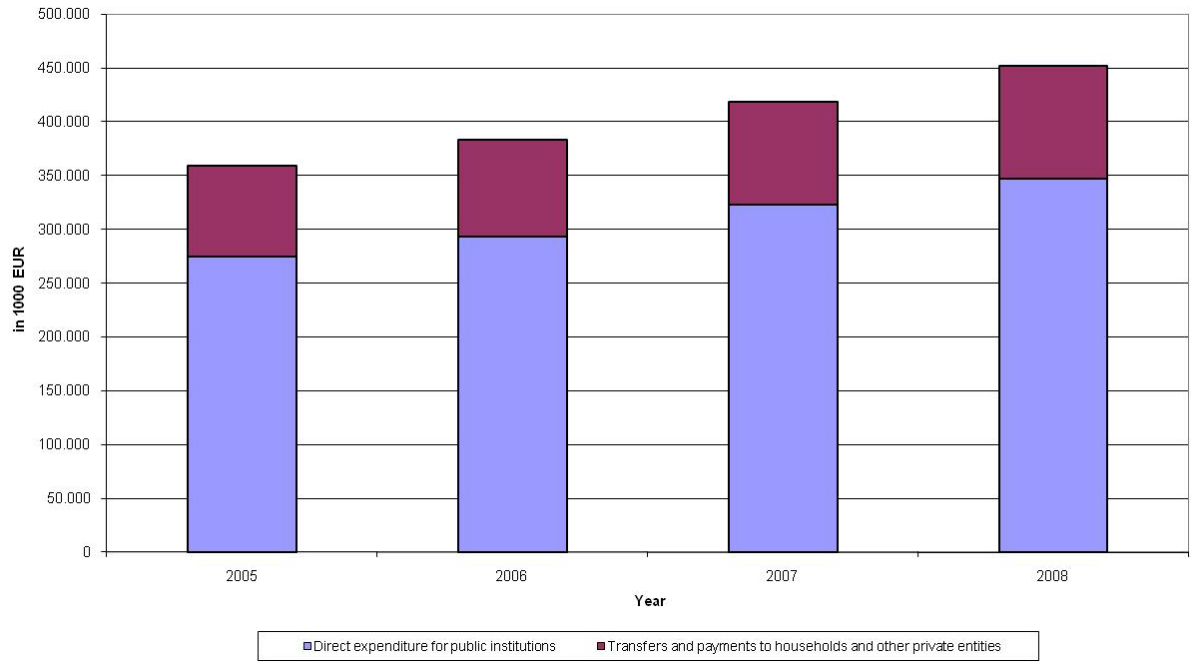


Figure 4: Public expenditure on tertiary education by purpose in the years 2005-2008 in 1,000 EUR (Statistical Office of the Republic of Slovenia, 2011).

Slovenia is among the countries with the dual system of tuition fees in which students who on a basis of their matura examination results enrol in full-time first- and second-cycle studies (if a graduate acquires a higher level of education), which are funded by the state, do not pay any tuition fees, while part-time students are charged tuition fees which are paid by them or by their employer. The state finances study activities by directly allocating funds to HEIs carrying them out – in addition to public HEIs, they also fund study programmes of certain private HEIs for which they have acquired a concession. In 2010, the concessions were allocated 4.1% of all public funds for study activities.

In 2004 Slovenia introduced a lump sum financing of teaching at HEIs, which was supposed to cover salaries (for teaching staff and administration related to teaching activities), and material costs for full-time studies at undergraduate and second-cycle master study programmes. Lump sum included historically based fixed part (60% in 2010) and normative part, which was calculated in dependence of the number of students, graduates, six tariff groups with different factors.

Table 2: Number of undergraduate and master full-time students and graduates of full-time undergraduate studies taken into account in the lump sum formula.

(Budget) year (Y)	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Academic year	**2002/03**	**2003/04**	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**2008/09**	**2009/10**
Undergraduate students	49.818	50.568	51.873	52.462	53.229	53.848	52.679	52.803
Master students (2. cycle)	-	-	-	-	112	675	1.685	3.635
Students total	49.818	50.568	51.873	52.462	53.341	54.523	54.364	56.438
Graduates (Y-1)	7.460	7.789	7.585	7.845	8.048	8.150	8.105	8.098
EUR per student*	3.228	3.445	3.574	3.725	3.781	4.058	4.670	4.455

Remarks:
* Estimated funding per student is calculated on the basis of public funds allocated to HEIs for study activities.
Source: Lesjak et al, 2010.

One of main reasons the system remained in use (with a few changes) until 2010 is in the fact that the budget for lump sum was increasing annually – in period 2003–2010 by 156%. It was only in 2010, when the funds for lump sum were for the first time nominally the same as in previous year that the full effect of normative part of the lump sum formula showed. Due to the decrease in the number of undergraduate students as a consequence to (Bologna) HE reform and demography the operations of Slovene's universities could be seriously endangered. On one hand they were not able to attract more public funds through normative part of lump sum formula and on the other hand they did not prepare themselves for the loss of income from private sources namely tuition fees for undergraduate part-time studies and scientific master programmes, which were abolished in 2009. On national level it was expected that HEIs will develop a market for (so-called) HE lifelong learning short study programmes.

Consequently new lump sum financing system for teaching at HEIs for full-time studies (1^{st} and 2^{nd} cycle) was introduced in 2011. In comparison with the previous financing system, the new lump sum represents 100% of value from 2010, which can be increased or decreased by 3% each year. This variable part is calculated through three indicators which measure the improvement of value compared to the previous year in:

- completion rate of current generation of students that should graduate taking into account the duration of study programme plus one year,
- progress of students from first into second year of studies, and
- international incoming and outgoing mobility of students.

The main limitation at setting the indictors was the availability of data on the level of student. The data exists on HEIs, but not on national level. It is expected that the new information system on HE will solve this problem within next two years.

Example of measuring the performance of Slovenian HE

Figure 5 shows how Slovenia is placed in the described matrix. Slovenian HE is definitely very accessible, but we doubt that we are the leaders with regard to HEI's capacity to attract funding for research and development from businesses. Particularly problematic is the fact that we lag behind in cost-effectiveness and the employability of graduates which are crucial for the effectiveness of HE.

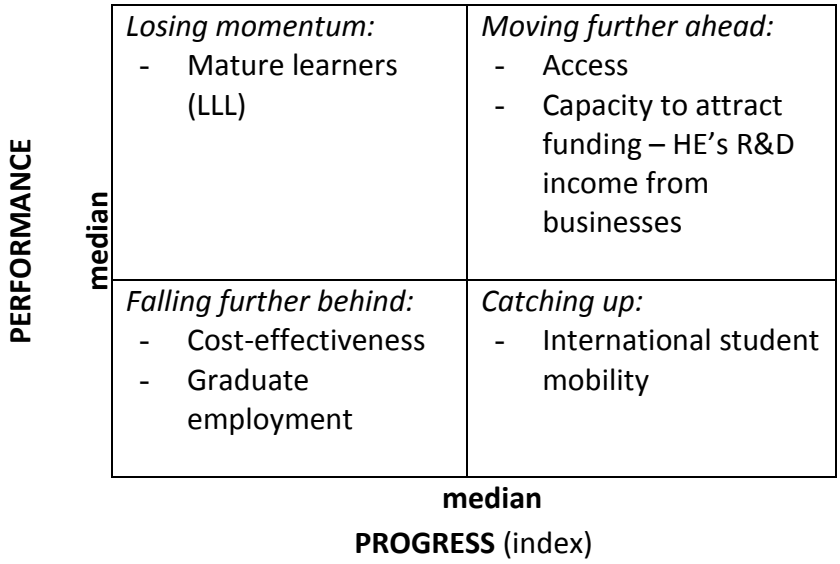


Figure 5: Placement of Slovenia regarding the effectiveness of HE performance (Jongbloed et al, 2010; Lesjak and Marjetnič, 2010)

Mechanisms for ensuring good governance of public funds in HE

To ensure efficient and effective operation of the HE system and HEIs in Slovenia, a number of mechanisms and institutions have been established. Table 2 presents some of the more important mechanisms, which we divided into direct and indirect, and preventive and control mechanisms in terms of the implementation of higher education activities by HEIs.

Table 3: Mechanisms for ensuring good governance of public funds in Slovenian HE.

Mechanisms	Direct	Indirect
Preventive mechanisms	- Accreditation of HEIs and study programmes by SQAA - National Register of HEIs kept by MHEST - Matura – national external secondary school leaving exam - Government's approval of the call for enrolment in HE - Publication of the call for enrolment in HE - Centralised application and selection procedure at the undergraduate level - Internal evaluation carried out by HEIs - Field and international accreditations (e.g. EAEVE, EQUIS, FIBAA)	- Administrative board of public universities - Annual work programme of HEIs - Annual report of HEIs - Internal audit and internal control of public funds of HEIs - Certification of management systems (ISO 9001 etc.) - Participation of HEIs in projects co-financed by EU funds
Controls	- Evaluation of HEIs and study programmes by SQAA - MHEST controls - International university rankings (Shanghai ranking, THE-QS, WEBOMETRICS, etc.)	- Budget Supervision Office of the Republic of Slovenia - Court of Audit of the Republic of Slovenia - Labour Inspectorate of the Republic of Slovenia - Corruption Prevention Commission - Market Inspectorate of the Republic of Slovenia - Inspection of the Public Sector Salary System (formerly the Ministry of Public Administration and departmental ministry)

Legend: SQAA – Slovenian Quality Assurance Agency for Higher Education, MHEST – Ministry of Higher Education, Science and Technology

With the introduction of lump sum funding, the state to a large extent entrusted the implementation of the HE policy strategy to HEIs. Therefore, it has become even more important that the state has an established methodology and system for monitoring the efficiency of using public funds in HE on the basis of the outcomes of HEIs (e.g. the length of study, study completion rates, employability of graduates, publications in renowned journals, citations of authors, cooperation with the economy and wider environment) and indirectly through the factors affecting the efficiency of HE (e.g. the quality and level of knowledge of secondary education).

If we continue to derive from the study of the efficiency and effectiveness of tertiary education (St Aubyn, 2009), the efficient use of resources has a positive impact on the total factor productivity and technological progress[2]. The first results of the continuation of this study, which compares the efficiency of tertiary education in the EU member states, show that Slovenian tertiary education operates **below its capacities**. Slovenia has relatively high investments in tertiary education which probably means that it does not use them best according to the indicators of HE performance, i.e. a large number of students who study for

[2] Total Factor Productivity is calculated as the difference between the growth of productivity and the growth of the employment of all production factors (capital, work, material costs).

a long time or never complete their studies, and the low efficiency of research given the small impact of numerous papers, as measured by citations.

CONCLUSION

This paper shows how complicated it is to search for the answer to the question of whether (public) funds in Slovenian HE are used efficiently, as there is no simple and unequivocal answer to this question. Furthermore, it is even more difficult to answer the question of whether we use the funds wisely, that is, if we realise the aims of the HE policy, and effectively, referring to the employability of graduates, their salaries and their contribution to society.

Efficiency is one of the key factors of effective HE, as are quality, excellence, etc. All these factors should contribute to achieving the HE development strategy included in countries' strategic documents – in Slovenia, mostly in the Master Plan for Higher Education.

We must keep in mind that in the field of HE governments face numerous, often conflicting, challenges, e.g. how to ensure:

- equal access to HE,
- HE funding and its fair allocation, and
- the accountability of HEIs in terms of the quality of education, and dedicated and efficient use of resources

without infringing on HEI's autonomy.

The eternal challenge of the state (government) is to find the right balance between HEI's autonomy and the necessary regulation of HE. The challenge of HEIs, on the other hand, is how to balance their autonomy with appropriate accountability to all stakeholders in HE.

The aim of the state is to provide the necessary conditions for effective HE which allows for equal opportunities, offers quality education and supports sustainable development of the country (and the EU). Therefore, HEIs, governments and other actors must be aware of their roles in the "knowledge society", and take responsibility for ensuring the expected economic, social and cultural prosperity.

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C3 – Business Networks

C3.1 **Business relationship coordination during extended project supply process**
Ilkka Ojansivu

C3.2 **Case study of creating a service business ecosystem**
Jukke Malvalehto

C3.3 **Decentralized bio-chp plant supplier candidates' collaborationwithin their business networks**
Matti Lehtovaara

C3.4 **Partner selection and collaborative relationship in the collaborative commerce**
Ming-Hsien Yang

BUSINESS RELATIONSHIP COORDINATION DURING EXTENDED PROJECT SUPPLY PROCESS

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ABSTRACT

This research deals with business relationship coordination during extended project supply process in service intensive project business. The focus of the research is to describe and explain problems faced in relationship coordination between project buyer and seller along different stages of the project supply process. In order to acquire a more complete understanding of the phenomenon a theoretical framework combining IMP-related interaction research and project supply process research is created and empirically grounded. According to the empirical findings, the main challenge of coordination is the fluctuating interaction between project stages, reflected in high employee turnover, communication problems and challenges in controlling customer responsibility. This research contributes to the micro level interaction research, by building a pattern between coordination processes and stages of the extended project supply process. Managerially findings are interesting, because they reveal fundamental problems in relationship coordination, followed by practical solutions into overcoming them.

Keywords: interaction, coordination, project supply process, relationship discontinuity, service intensive project business.

INTRODUCTION

The research on project business can be divided into studies on the understanding of project business characteristics (e.g. Artto & Wikström, 2005; Söderlund, 2004), project-based firm as a type of organization (e.g. Hobday, 2000; Whitley, 2006) and to research that aims to understand business relationships in this specific context (Bansard, Cova & Salle, 1993; Cova & Holstius, 1993; Hadjikhani, 1996; Alajoutsijärvi & Tikkanen, 2000; Skaates & Tikkanen, 2003; Cova & Salle, 2006). The lastly mentioned research stream, which is the focus of this research, emphasizes the distinctive features of project marketing, namely discontinuity, uniqueness and complexity of projects (Mandjak & Veres, 1998, Hadjikhani, 1996) resulting in specific types of business relationships. Majority of this research has been IMP related, highlighting interactive relationships and networks as the core phenomena (Ahmed, 1993; Alajoutsijärvi, Möller & Rosenbröijer, 1999; Cova, Mazet & Salle, 1996; Skaates & Tikkanen, 2003; Skaates, Tikkanen & Lindblom, 2002; Welch et al., 1996).

Research into interaction between project buyer and seller can be further divided to three broad categories. The first stream of research is concerned with managing individual projects from beginning to end. At this level research has concentrated on mapping the activities of the project supplier in different stages of the project supply process (Cova & Holstius, 1993; Cova, Mazet & Salle, 1994; Cova, Ghauri & Salle, 2002). These studies give a detailed view of the tasks project supplier needs to accomplish in order to acquire a project, but les attention is given to activities following project contract and especially project completion (Mandjak & Veres, 1998). The second stream of research deals with interaction during multiple sequential project deliveries and projects are regarded as "episodes" within long-term development. This IMP-related research has contributed our knowledge on the development of project business relationships. However, stages of the project supply process are overlooked, as projects are viewed merely among other episodes (Håkansson, 1982; Ford, 1990). The third research stream aims to understand discontinuous interaction after project completion by studying social dimension of business relationships. Accordingly, maintaining a structural relationship after project completion is viewed problematic (Skaates, 2000) due to absence of contractual obligations, which has given birth to concepts such as sleeping relationships (Hadjikhani, 1996), milieus (Cova, Mazet & Salle, 1996) and ritual approach (Cova & Salle, 2000). However, this kind of thinking is becoming quite obsolete, as project business involves increasingly service business characteristics (Artto, Wikström, Hellström & Kujala, 2008; Tyler, Patton, Mongiello & Meyer 2007; Skaates & Cova, 2005). Today, economic exchange rarely dissolves after project completion and many project-based companies are actually earning more revenues from project-related services than from project deliveries (Gebauer, Edvardsson, Gustafsson & Witell, 2010).

From the literature review it comes evident, that the previous research does not describe adequately interaction between project buyer and seller during the different stages of the project supply process, not to mention research that would consider different aspects of interaction. However, previous research has pointed out challenges in relationship coordination, resulting from information break up points between project stages (Skaates & Tikkanen, 2002, 399). This is also inline with difficulties pointed out in the temporary project organization literature (Engwall, 2003; Lundin & Söderholm, 1995; Packendorff, 1995). It has been also shown, that albeit interaction tends to fluctuate along project supply process, each stage can be associated with certain interaction characteristics, which appear generic into some extent (Ojansivu, Salo & Alajoutsijärvi, 2011). This implies, that the main problem of relationship management is not fluctuating interaction as such, but coordination between stages. Following the previous reasoning, this research proposes the subsequent research questions: 1) how does fluctuating interaction between project stages affect relationship coordination, and 2) what type of managerial actions can be taken to overcome the resulting challenges?

The empirical setting of this research is build around a single case study of a content management systems (CMS) supplier. These systems are supplied as projects requiring approximately 50% customization depending of the customer. Project completion is followed typically by service exchange ranging from basic maintenance to state of the art R&D. In general, CMS-systems are used in large organizations for creating and maintaining electronic services online. All to-

gether, supply of CMS-systems can be considered to be a typical service intensive project business by nature. In this research the term "service intensive" is used in order to describe project business, where service exchange accounts for a significant part of the turnover. According to the empirical findings, relationship coordination is strongly affected by the fluctuating interaction during extended project supply process. This can be seen in the high employee turnover in customer surface, communication problems and challenges in controlling customer responsibility. Furthermore, an empirically grounded framework anchoring certain coordination characteristics to each project supply stage is put forward

This research includes five sections. After introduction, the theoretical foundations of the study, comprising project supply process models and interaction processes and modes in the context of service intensive project business, are discussed and the theoretical framework is put forward. The third section describes the research design and methodology of the study. The fourth section, presents the empirical findings of the research. In the final section, the findings of this research are discussed and an empirically grounded framework is put forward. The limitations of the study are also considered and further avenues for the research explored.

BUSINESS RELATIONSHIP INTERACTION AND COORDINATION

Interaction processes form the backbone of business relationships. Generally speaking, interaction in buyer-seller relationship can be described with three basic processes: exchange process, coordination process and adaptation process (e.g. Håkansson, 1982; Möller & Wilson; 1988). Exchange processes are at the core of the interaction. Exchange is described usually with four types of elements: product or service exchange, information exchange, financial exchange and social exchange (Håkansson, 1982, 16). Adaptation processes refer to actions that interacting parties perform in order to benefit more from the exchange relationship. These actions can include modification of resources, skills, operations and even goals, attitudes and managerial values (Möller & Wilson, 1995, 27). If adaptations require investments that are relationship-specific, this may lead to increased relative dependence and high switching costs between the interacting parties. Non-retrievable investments are relationship-specific commitment of resources that cannot be recovered if the relationship ends (Lohtia & Krapfel, 1994; Wilson, 1995). Coordination processes have to do with mechanisms that facilitate the control of exchange processes. These mechanisms include decisions, rules and procedures as well as the "terms of trade" that all contribute to the efficiency of the relationship (Möller and Wilson, 1995, 27).

When project suppliers and buyers interact in specific way for a certain period of time, different interaction modes develop (Campbell, 1985; Möller & Wilson, 1988, 1995) and by viewing these modes in longitudinal setting, it is possible to understand the long-term development pattern of the relationship (Alajoutsijärvi, Möller & Rosenbröijer, 1999). Broadly speaking, project supplier and buyer may follow four "extreme" interaction modes: cooperative, competitive, command and submission (Campbell, 1985; Möller & Wilson, 1988, 1995). Business relationships represent seldom these four "extreme" interaction modes, but tend to be combinations of

them, which is why Alajoutsijärvi et al. (1999, 25) propose a "diamond" framework that views the four alternative relationship modes on a diamond-shaped space divided to two continuums; competition-cooperation and the buyer's versus seller's dominance. Each of these modes can be linked to certain relationship characteristics, which epitomize the behavior in the project supplier-customer relationship. According to this framework, relationships develop through interplay of different modes, which can be depicted as a shift on the diamond surface. Development requires, however, project supplier and buyer to have a quite similar mindset; otherwise the relationship becomes soon dissolved.

"Diamond" framework has proven successful in describing and explaining cyclic interaction between a paper mil and paper machine manufacturer in the context of multiple project deliveries (Alajoutsijärvi, 1996). It has been later modified by Ojansivu et al. (2011) to describe and explain interaction during single project delivery viewed in extended setting in the context of service intensive project business. According to their findings, albeit interaction tends to fluctuate along project supply process, each stage can be associated with certain interaction characteristics, which appear generic into some extent. This implies, that the main problem of relationship management is not fluctuating interaction as such, but coordination during transition from one stage to another. This research further elaborates the empirically grounded framework from Ojansivu et al. (2011) in order to focus on relationship coordination along the extended project supply process in service intensive project business (Figure 1).

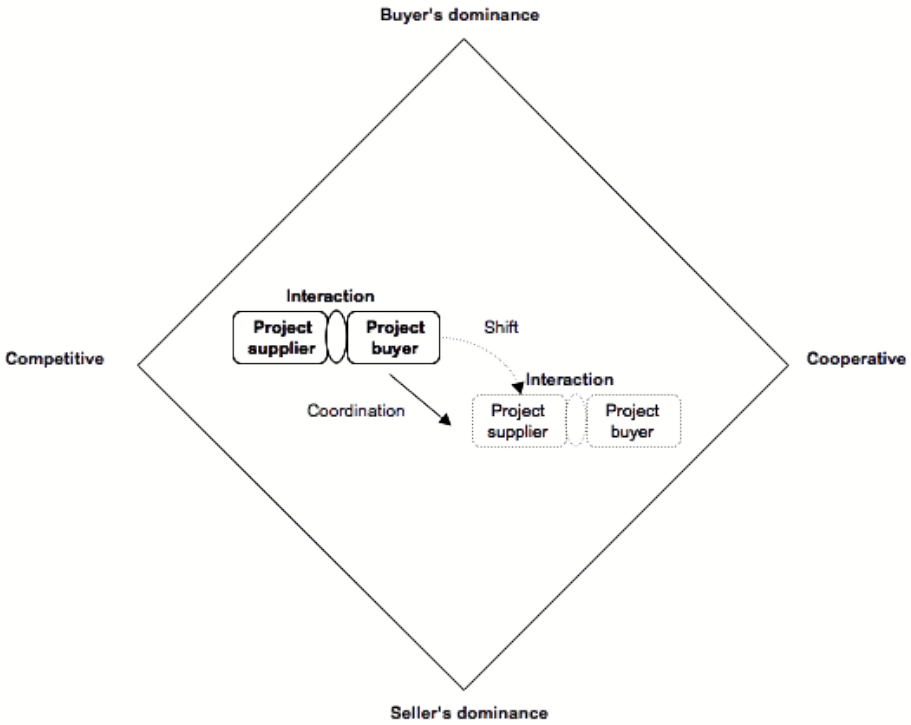

Figure 1: Theoretical framework: relationship coordination during a shift in the interaction processes and modes along stages of the project supply process.

In the framework an "extended" view to projects is adopted (e.g. Artto, 2001; Mandjak and Veres, 1998) in order to describe and explain coordination during the entire project supply process. Consequently, project is split to three general periods: pre-project, project and post-project. Pre-project stage starts from the first contacts between the parties directed towards cooperation. Signing the project supply contract means beginning of the project stage. When the project is delivered to the customer, so that it can start to use the system, project moves into post-project stage. From this point onwards further exchanges are viewed as service exchanges, not as incremental projects. Post-project stage continues until the supplied project is replaced with another one.

When project progresses from one stage to another, content of the interaction processes and modes changes along the way, which is reflected as a shift in the diamond surface (Ojansivu et al, 2011). Different tasks take place between project supplier and buyer during separate project stages requiring particular content of interaction processes. Therefore progress in the project creates changes in exchanges, coordination and adaptations between the parties. For example, if interaction mode turns into competitive and submission, exchanges are dealt on short-term basis, coordination is bound to turn formal and adaptations are minimized. It has been shown, that project stages represent possible information break points in the relationship, because the organizational structure in the supplier company becomes adjusted (Skaates and Tikkanen, 2002, 399). Coordination is needed, in order to facilitate the transition between stages.

RESEARCH DESIGN AND METHODOLOGY

The methodological choices of this research are guided by the basic aim of expanding existing knowledge of relationship coordination during extended project supply process the context of service intensive project business. Due to the novel nature of this phenomenon and the complexity of project business in particular, single case study has been chosen as the method of this inquiry (Stake, 2000, pp. 435-454). The author collected all the data specifically for the purpose of this research. The main data source through which the relationship coordination will be described consists of semistructured interviews (Kumar, Stern & Anderson 1993; Arksey & Knight, 1999) of employees of the supplier firm and its main three public customers (see table 1). The choice of informants was premised on the principle that information is best elicited from people who have knowledge of relationship coordination. Although other respondents working in the same company could have offered additional viewpoints on this subject, a key informant from each company was chosen based on the understanding, that he was actively involved in the relationship and thus able to provide explicit and definite insight into it. All the interviews were taped with the interviewee's permission and then transcribed and analyzed accordingly. Qualitative data analysis was employed in order to thematize the material (see Miles & Huberman, 1984). Documents, minutes of meetings, industry reports and company visits were used to triangulate the respondents' answers, as suggested in literature (Patton, 1987; Denzin, 1978). Data triangulation was first used to compare the different perspectives presented by each of the interviewees and, subsequently, to compare the interviews with other sources, such as industry reports, in order to validate our observations and interpretations (Denzin,

1978). The results are presented in the next section. The identities of the companies or the respondents are not revealed for reasons of confidentiality.

Table 1: Interview data.

Company	Position	Date, and duration of the Interview
Alpha	Business unit manager	May 2006 (1 h)
	Chief executive	December 2005 (2 h)
	Chief project manager	July 2006 (2 h)
	Project manager (a)	May 2006 (2 h)
	Project manager (b)	June 2006 (2.5 h)
	Leading application designer	June 2006 (1.5 h)
	Sales manager	December 2005 (2 h)
City	IT Project manager	July 2006 (2 h)
Uni	Application designer	June 2006 (2 h)
Edu	Development manager	June 2006 (2 h)

BUSINESS RELATIONSHIP COORDINATION: A SINGLE CASE STUDY

The empirical setting of this research is build around a single case study of a content management systems (CMS) supplier. The goal of the empirical research was to increase understanding of challenges related to relationship coordination during extended project supply process. Besides of the company representatives working in the customer surface, also three main public customers of Alpha were interviewed to achieve customer perspective to coordination and data triangulation. These customer are a medium size town in Finland referred onwards as City, an University called Uni and an educational federation of municipalities namely Edu. The supplier company of the case study, Alpha, was founded in 1997 to develop web-technology based systems and digital user interface design. The main product of Alpha, and the subject of exchange in the case relationships, is a content management system (CMS) referred onwards as AlphaWeb, which customer receives through the ownership of a license, but whose intellectual property rights (IPR) holds the supplier. AlphaWeb projects can be described as fairly unique and complex requiring on average 50 percent tailoring. Alpha functions in typical service intensive project business as it provides a variety of services ranging from basic maintenance services to more sophisticated development, education and consulting services. Yearly revenue for Alpha is around 4,36 million euros.

Coordination in the pre-project stage

Typical AlphaWeb delivery begins long before the formal competitive bidding process by informal social networking between the sales and marketing people from Alpha and its potential customers. It is also typical that the customer orders first a minor application from Alpha to check its reliability. Thus, when the bidding process begins, Alpha has already a social relationship to the provider of the bid. No ties are yet formed and interaction is restricted mostly to information and social exchange between the sales people of Alpha and its customer candidate. In this stage buyer has typically dominance over the competing suppliers as long as the contract

remains plank. However, if a social relationship exists, dominance becomes lesser and bidding process might even represent a "show" just to play by the book. Coordination at this stage is formal and customer applies arm's length approach to keep the distance to the suppliers and make them compete for the winning bid. Challenges begin to appear after project contract has been signed and the actual project delivery begins, because promises made by sales persons have to be met on technical level during the project. Project management of Alpha was suffering from the unrealistic promises as pointed out by Alphas leading project manager: *"On one occasion sales person had been visioning stunning and extremely expensive ideas and was thus able to acquire the customer. After this it was the project manager's responsibility to keep the unrealistic and overhyped promises from the sales person as best he could with his technical knowhow."* This communication problem related to the organizational structure of Alpha. Project managers felt that they were a "lover rank" in the company hierarchy because they did not have permanent function as sales and marketing had. Project managers went from a project to another one quickly and were involved with customer only during the active implementation. Project managers felt that problems faced in project specification were neglected and project management was not in the position to complain as Alphas project manager B stated: *"After all you feel that because sales division is higher in the company hierarchy than project management, so we are just, we are just ordinary mortal."* Sales people on the other hand did not know much about the technical details, as they were more interested of the potential sale than the following delivery. One of the concurrent problems was timing of the project that was seen by sales people very optimistically, which was causing delays in delivery, stress for project managers and unhappy customers. This created tension between these two professional groups as clarified by Alpha's leading project manager: *"At the moment our sales people don't have the required technological know how. They know the small talk and are thus able to bring the customers in, but when thinking of customer responsibility, well it's another thing. Basically sales people bring the customers in, but afterwards everything is unclear, and the same stuff goes on today."*After Alpha had won the competitive bidding process and acquired the customer, sales people and possibly upper management involved in the negotiations stepped aside from the relationship and moved customer responsibility to the project manager and project team.

Coordination during the project stage

Project stage began by Alpha setting up the project team including at least an application designer, graphic designer, software developer and a project manager. It was project managers task to continue from where the sales people had left after contract signing. This was challenging, because project implementation required more cooperative interaction with the customer, because all the necessary details had to be discussed and the system tailored according to the customer preferences. From the customer perspective, this was the time when most of the social interaction took place and the project team members of Alpha became known, as highlighted by the development manager of Edu: *"Of course in the development phase and during the system implementation we knew all software developers who were working for us and we almost acted like…well, we didn't gave them direct assignments, but nevertheless they were present in meetings so we could communicate with them directly about problems in hand and*

guidelines for product development." The important role of the project team shifted the power balance to Alpha that was obligated to deliver according the project contract. At this stage, depending of the project characteristics, adaptations started to take place between the interacting parties and coordination was needed to adapt schedules and work routines as expressed by Citys IT project manager: *"We could pay a visit to Alpha at anytime, talk things through in the phone and do rapid adjustment or updates…and when we had an emergency they would speed up their processes."* When project delivery came to an end and project team was dissolved, setting the customer responsibility proved to be difficult. Sales representative that had acquired the customer had stepped aside after contract signing and the project team members including project manager were already working on other projects, so it was challenging to held anyone directly responsible. However, project managers had often built a social friendship to the customers and they knew the customer specifications by heart, so they felt responsible for the customer as Alphas project manager B pointed out: *"As far as I understand the roles right, responsibility for the customer should stay with me after the project. I take care of all the practical things and the sales responsibility stays with the sales person. I don't know how it should be, but I personally feel responsible for the relationship. I can't just disappear after the project has ended. After all, I'm the one customer is calling after the project. This can be confusing for customers and I know occasions when customers have been struggling to find their primary contact person."* Customers were told not to contact directly any productive resources such as application or software designers after project ending. However, customers saw this as a strange arrangement, as they had formed personal relationships to these people during the project. Some customers persisted to contact software developers and application designers regardless of the advice from Alpha just to discover they were not there anymore.

Coordination in the post-project stage

In service intensive project business, post-project stage marks the end of the project supply process and beginning of the service supply process. From this point onwards Alpha viewed further exchanges as service exchanges, not as incremental projects, because post-project stage was seen to continue until the system is replaced with another one. Generally speaking, two opposite interaction modes were apparent during post-project stage. In the first one, business relationship continued as exchange of maintenance services**.** These services were very basic and did not require much interaction. However, due to the proprietary technology AlphaWeb contained, they had to be acquired from Alpha, which increased its power in the relationships. This type of interaction mode was not very cooperative as these services were delivered without direct contact with minimum inconvenience and therefore coordination was handled through electronic means. Actually most of Alpha's customers were in this stage as explained by Alphas project manager A: *"When we are dealing with a basic small customer, like an association or a small private sector company, business with them is usually active only during the implementation of the system. After this it turns pretty much to a maintenance type relationship and we don't have any project like activities going on with them anymore."* The second post-project interaction mode resource exchange is build upon development services, which require a more cooperative interaction mode. These services often included consulting and develop-

ment activities and marked sizeable profits for Alpha. In addition, Alpha was able to further benefit from this interaction mode, as it was able to build simultaneously its own technological capability. It was, however, difficult to find customers who had the resources to invest heavily on R&D, so if a potential customer appeared, it gained more power in the relationship. In this stage coordination was most concerned with relationship continuity, as Alpha tried to keep the cooperative service exchange going. Alphas leading application designer highlighted the important role of project managers in this stage: *"It is part of our unwritten guideline and success that project managers have known their customer's situation perfectly. So, they have been able to offer services, such like development and further development services and played the role of a consulting person…It has been our strength, as it builds the size of the delivery, and then we are not just selling licenses anymore."* Problems appeared when customers that had been involved only with basic maintenance services begin to develop their system. At this point their know project managers could have moved away and be replaced with new ones that did not possess all the necessary knowledge of the relationship history as described by Alphas project manager A: *"It was challenging to build relationships to customers that were accustomed to another person, who had been responsible for the original project. It was especially hard, because these customers had been on a maintenance stage for long, much longer than I had worked for the company."* This phenomenon appeared to be a continuing problem in Alphas customer relationships and one of the reasons for the interaction to turn from active development back to passive maintenance. The application designer of Uni pointed out the frustration regarding this issue: *"Of course certain things have been left unfinished, or we have agreed things with the previous person and then the next one has not been aware of these because information has not been passed from a project manager to another project manager."* Alpha's project managers explained that this was not a straightforward issue, because project manager's resources were scarce and customers were plenty. That was the reason why project managers had to priories and decide which customers earned more attention than others as explained by Alpha's project manager A: *"Communication with maintenance customers depends on the heaviness of their system use. Of course it makes a difference whether the customer has only a small and basic website where only topical information is maintained or an active environment where 250 people are involved in updating the website every day."* It seemed that there was no simple solution for the customer responsibility problem along the different project stages. General impression was that sales people in the pre-project stage should be replaced with persons possessing wider understanding of project business and technical details of projects as the leading project manager of Alpha pointed out: *"One should get rid of the sales representative and replace him with an account manager type of person, who would understand business, technology and the product to be sold."* It was considered important that same person would stay in the relationship from the beginning so that customer responsibility would not be transferred between project stages. Therefore using an account manager only after project completion was seen unwise, because then all the customer specific information would be jeopardised as project manager B of Alpha pointed out: *"I don't think that using an account manager for all the old customers would solve anything. According to my knowledge, it's best to have one project manager responsible for the customer from the project implementation onwards, so that responsibility is not shifted again to another person."*

ANALYSIS

The single case study reflected challenges in business relationship coordination along different stages of the project supply process. In the pre-project stage main tasks of coordination related to creating and maintaining social relations to potential customers and after project negotiations got underway interaction changed to more formal consisting of information exchange and buyer's dominance during the competitive bidding. Sales people and upper management from Alpha were in charge of the contract negotiations and formal meetings. Main task of coordination was to create technically realistic bids that were at the same time compelling for customers. The role of the sales people in the pre-project stage was questioned, because they did not posses the required technical knowledge of the product and were therefore causing problems for the subsequent project stages. Educating sales people of project business special characteristics and improving their knowledge of the supplied system could improve the situation.

Project stage was more or less a rapid specimen of project team's skills to implement the system, which shifted the relationship to a more cooperative setting and increased supplier's power in the relationship. Exchange included information, social, economic & technologic aspects needed to finish the project on time and budget. Coordination activities were dependent on project characteristics, with more complex and unique projects demanding wider organizational interaction. The main challenge was to implement the often abstract and highflying sales speech that could be misleading with reality. Improving communication between sales and project people was seen as a possible solution, but would be difficult to accomplish, because the company hierarchy that highlighted sales departments position in the organization over project management. This made sales people reluctant to care about business relationships after customer had been acquired and contract signed.
Post-project stage proved to be an evolving one, with interaction activities moving from development to maintenance and vice versa. For the period of development activities communication was intensive and kept personal. These activities required interaction between various organizational levels and professionals and therefore relationship turned into a more cooperative setting. Relationships were generally neutral or buyer dominated, which occurred if the customer had exceptional resources. Most of the adaptations were formed during development activities when system was tailored and new applications created. Interestingly, customer responsibility was often unclear as it was dependent on project characteristics, but it usually involved project or sales manager. Not surprisingly, the main challenge of coordination was to improve communication between sales and project people. This was needed to achieve a more consultative approach towards customers integrating sales knowledge with technological understanding. Alpha was not able to continue this stage perpetually as relationships turned finally into maintenance.

During maintenance activities relationships were passive and communication was organized non-personally by using electronic CRM. Relationships tended to be competitive and supplier dominated, because customers did not have a choice due to earlier relationship specific investments. Maintenance activities did not cause other than psychological ties at most, because

interaction and further investment were kept minimal, but the previous structural ties remained unchanged. The main problem of coordination was to disconnect customer from the project team members and project manager after project implementation or active development activities. This was necessary, because project team members were working already on other projects and therefore busy. This was bizarre in a sense, that it was Alpha's best inters to continue active development activities as long as possible, but at the same time there was not enough resources to keep active interaction going, if customers were not involved with development activities. As a way out of this problem it was suggested, that project managers should be kept in charge of the relationships after project implementation permanently. This would however require more resources for project managers that were already tremendously busy. Table 2 summarizes the findings of the case study.

Table 2: Summary of the findings: relationship coordination during extended project supply process.

Project stages	**Pre-project**	**Project**	**Post-project Maintenance**	**Post-project Development**
Persons involved with coordination	Sales & upper management	Project manager & project team	Non-personal electronic ways	Unclear
Tasks of coordination	Social interaction & winning bids	Successful project implementation	Problem solving with minimum inconvenience	Further service sales & relationship continuity
Challenges of coordination	Creating tempting but realistic bids	Implementing the abstract sales speech	Disconnect customer from the project team members	Interaction between sales and project management
Proposed solutions for coordination	Educate sales people of project business characteristics	Improve communication between sales and project people	Keep the project manager in charge of the relationship	Replace sales speech with consultative problem solving

DISCUSSION AND CONCLUSIONS

In the present study relationship coordination during extended project supply process in the context of service intensive project business has been explored. The Focus of this research has been to find out, how fluctuating interaction between project stages affects relationship coordination, and what type of managerial actions can be taken to overcome the resulting challenges. Based on the literature review, a theoretical framework was constructed, portraying relationship coordination during a shift in the interaction processes and modes along stages of the project supply process. Based on the findings of the single case study, an empirically grounded framework for relationship coordination in service intensive project business in proposed in the figure 2.

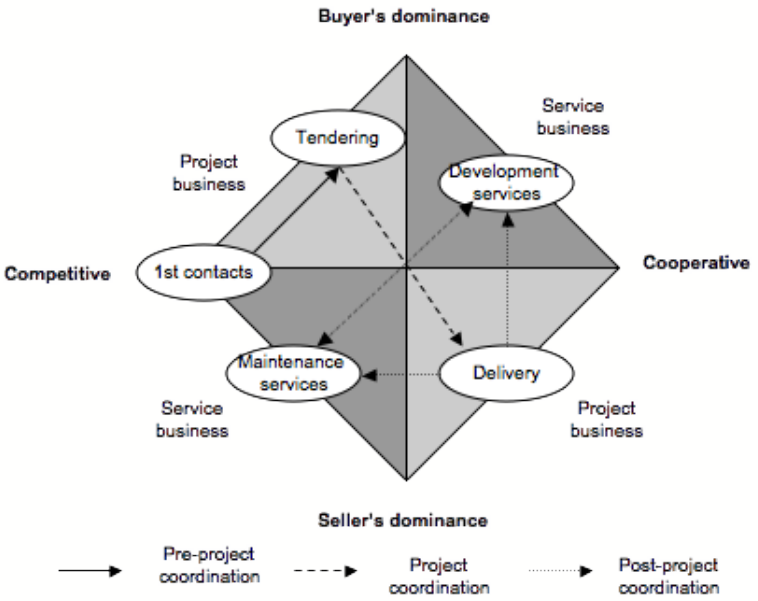

Figure 2: Empirically grounded framework for relationship coordination during extended project supply process.

In the framework the diamond shaped surface in divided to four sections, which each hold resemblance to a separate stage along the extended project supply process and require particular type of coordination depicted with specific arrows. It is acknowledged, that while business relationships goes through these stages, interaction processes and modes evolve concurrently. Each of these sections, however, reflects specific relationship characteristics predictable in advance. During the pre-project stage (the left upper quarter of the framework), interaction is limited to information exchange between sales people and customer and relationships are buyer dominated and competitive. In the project stage (the right bottom quarter of the framework) more cooperative setting is required in order to finish the project, yet the power balance shifts to the supplier who holds the written contract for the delivery. At this stage interaction is wider and coordinated by the supplier's project team. First minor adaptations take place, as the interacting parties adjust their work processes and schedules. This stage represents the first information break point in the relationship as the responsibility of the project is passed from the upper management to the project team (cf. Skaates & Tikkanen, 2002, 399).

After project has been completed, interaction revolves around service exchanges. Post-project stage resembles the second possible information break point in the relationship, as the project team becomes dissolved (cf. Skaates & Tikkanen, 2002, 399). In the framework, two opposite interaction modes for post-project stage are suggested. In the first one, business relationship continues after project completion as exchange of maintenance services (the left bottom quarter of the framework). These services are very basic and do not require much interaction between the parties, i.e. the relationship shares similarities with the sleeping relationship (Hadjikhani, 1996) with the exception of the continued economic exchange. These services are easy to produce, and if the supplied project requires proprietary technology they need to be acquired from the original project supplier (Ojansivu & Salo, 2010), which shifts the power to the suppli-

er. This type of interaction mode is competitive and passive as these services tend to be delivered without direct contact with minimum inconvenience.

In the second post-project interaction mode resource exchange is build upon development services, which requires a cooperative interaction mode (the upper right quarter of the framework). These services can include consulting and R&D and mark sizeable profits for the supplier. In addition, supplier can further benefit from this interaction mode, as it is able to build simultaneously its own technological capability (cf. Wynstra, Axelsson & van der Valk, 2006). It might be difficult, however, to find customers who have the required resources, so if a potential customer appears, it will most likely gain the power over the supplier. Depending of the service characteristics, adaptations create structural dependency between the interacting parties. Especially if the technology in the supplied project is proprietary (Teece, 1986; West, 2003) and the system is highly customized, high switching costs may appear (Lohtia & Krapfel, 1994; Wilson, 1995).

Interaction modes evolve during the post-project stage and therefore cooperative development service exchange may turn into competitive and passive maintenance service exchange and vice versa. It is managerially challenging to predict these changes and coordinate relationship accordingly. In the next section, these problems are addressed both theoretically and managerially.

Theoretical and managerial contributions

This research contributes to the IMP-related project business research, by deepening our understanding concerning business relationship coordination during extended project supply process in service intensive project business. Based on the literature review it was suggested, that the previous research does not depict interaction processes, not to mention coordination, during different stages of the project supply process. Therefore an “extended view” to projects was adopted to overcome the limitations of the previous research. Thus, project stages were not restricted to time before project contract like the previous supply process research had assumed and view of the project was not limited to an “episode” as the interaction research had assumed. Consequently, this research proposed a framework for relationship coordination during a shift in the interaction processes and modes along stages of the project supply process in figure 1.

Based on the empirical findings, relationship coordination is strongly affected by the fluctuating interaction during extended project supply process. This can be seen in the high employee turnover in customer surface, communication problems and challenges in controlling customer responsibility. Accordingly, an empirically grounded framework anchoring certain coordination characteristics to each project supply stage was put forward in the figure 2. Results support the previous findings of the information break points during project supply process; information accumulated during project negotiations from sales people and upper management has to be passed to project team during project stage and after project team becomes dissolved custom-

er specific information needs to be transferred to the next responsible person in the post-project stage.

Fluctuating interaction during project supply process is challenging managerially, because it affects relationship coordination. By connecting project stages into certain coordination characteristics, relationships are made more transparent and therefore manageable; managers can expect specific behavior from their counterpart along each project stage and review their own behavior accordingly. To translate the theoretical findings into practical ones, three aspects of fluctuating interaction require further examination relating to relationship coordination. First, sales people need to have knowledge of project business characteristics and they need to understand technological details of the supplied system. Secondly, relationship coordination is difficult when project progresses from one stage to another, and therefore replacing project managers during project should be avoided to the last resource and project managers should be kept in charge of the relationship starting from project implementation. Thirdly, customer specific knowledge derived from sales people, project managers and upper management during different stages of the project supply process should be secured in company databases and actively used. To conclude, long-term relationships require management attention and the supplier needs to be on tiptoes, because both ideas for product development and resources for product development arise from customers.

Limitations of the study

Business relationships are strongly embedded in their specific environment and therefore generalizations are challenging. In fact there exist only few models appearing as general relationship development frameworks (cf. Dwyer, Schurr & Oh, 1987; Ford, 1980). Current research is qualitative in nature and provides insights into service intensive project business, and especially CMS projects. Thus, results should be generalized with caution to other type of project business, while future research is needed to validate the findings in broader context. The role of this research was to open up new avenues for project business and project-related services research.

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CASE STUDY OF CREATING A SERVICE BUSINESS ECOSYSTEM

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ABSTRACT

This paper discusses the meaning of business ecosystem in business development, especially in value creation and offering development. The discussion is based on literature and a case study of service business ecosystem. Results are literature review, a case description of service business ecosystem, and critical analysis of ecosystem thinking in developing a new business. In this paper, a framework for modeling a business ecosystem was developed. Framework was also tested and a map of a service business ecosystem was presented and analyzed. Key findings were the actual roles of actors of the ecosystem and relationships between the actors. Few actors were controlling most part of value creation and revenue streams while most of the actors were only focusing on a niche portion of the ecosystem.

Keywords: Business ecosystem, value chain, value network, business model, service business

INTRODUCTION

Networked business is the reality for most companies in any industry. Business ecosystems are composed of hundreds of and even thousands of organizations globally. (Dittrich and Duysters 2007; Iansiti and Levien 2004b) Individual companies are dependent on success of the whole aggregate and thus face a vast challenge in their business development. To thrive sustainably in competition between rival ecosystems, development and innovation efforts of companies must benefit the ecosystem as a whole.

Ecosystem metaphor emphasizes network members' symbiotic relationships and dynamic nature of business network. Moore (1996) defines business ecosystem as "an economic community supported by a foundation of interacting organizations and individuals - the organisms of the business world." In a business ecosystem, companies co-evolve capabilities around new innovations by working cooperatively and competitively to support new offerings, satisfy customer needs and eventually discover innovations (Moore 1993).

This paper contributes scientific discussion of business networks by studying revenue streams and offering structures in developing a new business ecosystem. The study focuses on a single business ecosystem, which is considered as a closed system for the simplicity's sake. This system consists of three types of actors: consumers, businesses and operators. The research question is: ***How can the business models of actors be exploited in developing a new business ecosystem?***

For the background literature is reviewed. As a main contribution, a business ecosystem is modeled based on inside information of service business industry. To ensure the privacy of stakeholders, data discussed in this paper is reduced and disguised. Main managerial implications and conclusions are discussed from the viewpoint of business development in a business ecosystem. The main implications contribute on how business model approach can leverage the development of a new business ecosystem. The actors in ecosystem can utilize the model in positioning themselves in the ecosystem. In addition, external organizations can exploit approach described in this paper to model current state and determine potential development paths within the ecosystem they are involved.

THEORETICAL BACKGROUND

Modeling business models and ecosystems are fundamentally based on the mechanics of value chains and value networks. Therefore, theoretical elementary of value chains and networks are described first. Then business models and business ecosystems are introduced and finally theoretical background is synthetized.

The idea of value chains is introduced as industry level approach where each actor, or a firm, adds value to the product (Porter 1985). In a value chain, organizations are horizontally linked to each other and each provides products or services to the next operator in the chain (Porter 1985). Value chain can be considered as a group of sequential activities, which can be connected through information and resource flows. The ultimate goal of a value chain is to provide value to the end customer of the value chain.

In contrast to value chains, in value networks the value created is not only for the customer, but also for firms and societies participating in the network (e.g. Parolini 1999; Bovet and Martha 2000). In value networks, resource and information flows can run vertically and horizontally. These flows can be simultaneous and multidirectional. Therefore, the value network could be rather described as a web than a funnel like value chain. The value network can be as a network structure where actors are linked, vertically and/or horizontally, to each other through value exchange activities. The ultimate goal of a value network is to provide value to the end customer and actors participating in the network.

While value chain and network approaches focus on value creation, value capture functions are ignored. Therefore, it is essential to broaden our approach to business models to understand the role of value capture in an ecosystem. Next business model literature is introduced and summarized briefly.

Business model elements and components

Business models are actively discussed topic in literature during last fifteen years. As a consequence, dozens of various business model concepts and frameworks exists including up to fifty different business model components (Morris et al. 2005; Mäkinen and Seppänen 2007; Shafer et al. 2005). For this study couple of various and comparable business model definitions and frameworks is chosen for review. Those frameworks form a representative sample of literature that is presented at table 1. in terms of main elements and components.

Afuah (2004) defines a business model of a firm as a framework for money-making and explains business models as a strategic management approach. This framework is conceptualized through five main elements and embodies money-making aspects of strategies. According Osterwalder and Pigneur (2009) a business model describes the rationale of how an organization creates, delivers and captures value. Furthermore, Osterwalder and Pigneur (2009) explain the business model being like a blueprint for a strategy to be implemented through organizational structures, processes, and systems. It is broadly used model that is conceptualized through four main elements and nine building blocks. Shafer et al. (2005) define business model as a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network. This descriptive study is an example of many attempts to define business model by integrating and synthesizing earlier literature. According Suikki et al. (2006) business model describes the offering, the value chain or network, and revenue model of a firm. Suikki et al. (2006) designed their framework for describing and building business models in telecommunications industry. It provides an example of using business model for research purpose in industry settings.

Table 1: Business model elements and components in literature.

Author	**Main elements**	**Components**
Afuah (2004)	Positions	Customer value, market segments, revenue sources, price, relative position (vis-à-vis competitive forces)
	Industry factors	Competitive and macro forces, co-operative forces and industry value drivers
	Activities	Decisions of: Which activities to perform and which not, how to perform activities and when to perform activities?
	Resources	Resources (or assets: tangible, intangible and human), competences (or capabilities)
	Costs	Cost drivers of: industry, resource, activity and position
Osterwalder and Pigneur (2009); *Osterwalder* (2004)	Offer	Value proposition
	Customers	Customer segments, channels and customer relationships
	Infrastructure	Key resources, key activities and key partnerships
	Financial viability	Cost structure and revenue streams
Shafer et al. (2005)	Strategic choices	Customer, value proposition, capabilities/competences, revenue/pricing, competitors, output (offering), strategy, branding, differentiation and mission
	Create value	Resources/assets and processes/activities
	Value network	Suppliers, customer information, customer relationship, information flows and product/service flows
	Capture value	Cost, financial aspects and profit

Suikki et al. (2006)	Offering	Composition, customer and sales approach
	Value creation system	Structure, players and size
	Revenue model	Basic logic, cost and pricing structure, market and share of value

Mäkinen & Seppänen (2007) concluded that literature of business models is diverse and lacks unified taxonomy and conceptual groundings. Besides differences in naming and in hierarchical classification, there is divergence also in actual content of business models. Inside a firm, business model concept is linked with and somehow positioned between strategy and operational level in which activities and processes are carried out (e.g. Osterwalder 2004). It is being argumented whether business model includes competitive strategy, value capture aspects of strategy or is like a blueprint of strategy (Afuah 2004, Chesbrough and Rosenbloom 2002, Osterwalder and Pigneur 2009). Furthermore, Osterwalder and Pigneur (2009) and Suikki et al. (2006) exclude strategy from business model itself. Relations to external environment and actors outside a firm are variously described and included in business models. Besides customers, perception varies which actors should be included in business model by default. In addition, approach to value creation varies from value network to be based on resources and activities. Relation to environment is overextended in Afuah's (2004) business model framework compared to others. Especially, the main element of industry factors and its components are not built into others' business model frameworks. This study distinguishes industry factors from business model because those factors are not describing how an organization creating and capturing value.

Description of business ecosystem

Ecosystem metaphor emphasizes network members' symbiotic relationships and dynamic nature of business network. Moore (1996) defines business ecosystem as *"an economic community supported by a foundation of interacting organizations and individuals - the organisms of the business world. In a business ecosystem, companies co-evolve capabilities around new innovations by working cooperatively and competitively to support new offerings, satisfy customer needs and eventually discover innovation*s (Moore 1993). " Iansiti and Levien (2004b) describe business ecosystem as "*loose networks – of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organization – that affect and are affected by the creation and delivery of a company's own offerings*." Originating from biology, an ecosystem provides a rich analogy for understanding business networks. Those, as well as biological ecosystems are characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival (Iansiti and Levien 2004a).

These (biological) ecosystems has some specific features - the structure, the relationship among members, the kind of connections among members, and the differing roles played by their members (Iansiti and Levien 2004a). According Corallo et al. (2007) parties in a co-evolutionary relationship activate selective pressure on the other, and consequently affect each other's evolution. Economic and social aspects are emphasized in business ecosystem; its evolution is due to competitive and cooperative interactions of its members. Differing behavioral roles exist in every business ecosystem: very few keystones, few dominators,

large amount of niche players and few special members. In a business ecosystem, network is a key activity of members. Members share the total value that the ecosystem creates. Each organization adds one or more distinct aspect of offering value to the value generated by the ecosystem (Corallo et al. 2007)

Business model elements to describe ecosystem

In a simplified manner, *business model describes how a firm is creating and capturing value* (c.f. Shafer et al. 2005, Osterwalder and Pigneur 2009). Studied business model frameworks identify customer and firm's offering that proposes value to customer. The offering is the source of revenue. Value creation is built into all business models but emphasis is given on different aspects of it, such as resources, activities, value network and its participants. Costs are very basic element of all business models. Costs result from other business model elements. For example, using and maintaining capabilities and resources, making acquisitions from value network and delivering an offering cause costs for a firm. Main actors in business model frameworks are a firm and customer. In addition, different kind of co-operators, namely suppliers, partners and players in value network are mentioned in literature. As a summary and integration of business model frameworks, this study lists elements and components of business model for describing a business ecosystem in Table 2.

Table 2: Business model elements and components for describing business ecosystem.

Elements	Components
Actors	A firm, customer, co-operator
Value creation structure	Chain or network
Capabilities	Capabilities, activities, processes
Resources	Resources, competences
Offering	Offering
Revenue	Revenue logic, share of value
Cost	Cost of: resources, capabilities, position, downstream

Elements and components of business models include describes business ecosystem several ways. Offering and revenue are the basic elements for describing business relation between a firm and customer. To create value to offer and to deliver offering, a firm has own resources and capabilities as well as with the support of co-operators in value network. This approach on business models used in this study is depicted in Figure 1.

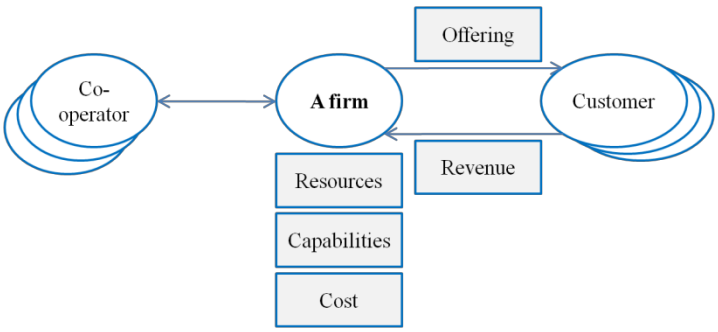

Figure 1: Business model framework and main components.

Utilizing the framework in Fig. 1, a view on business ecosystem based on actors' business models can be drawn as theoretical construction.

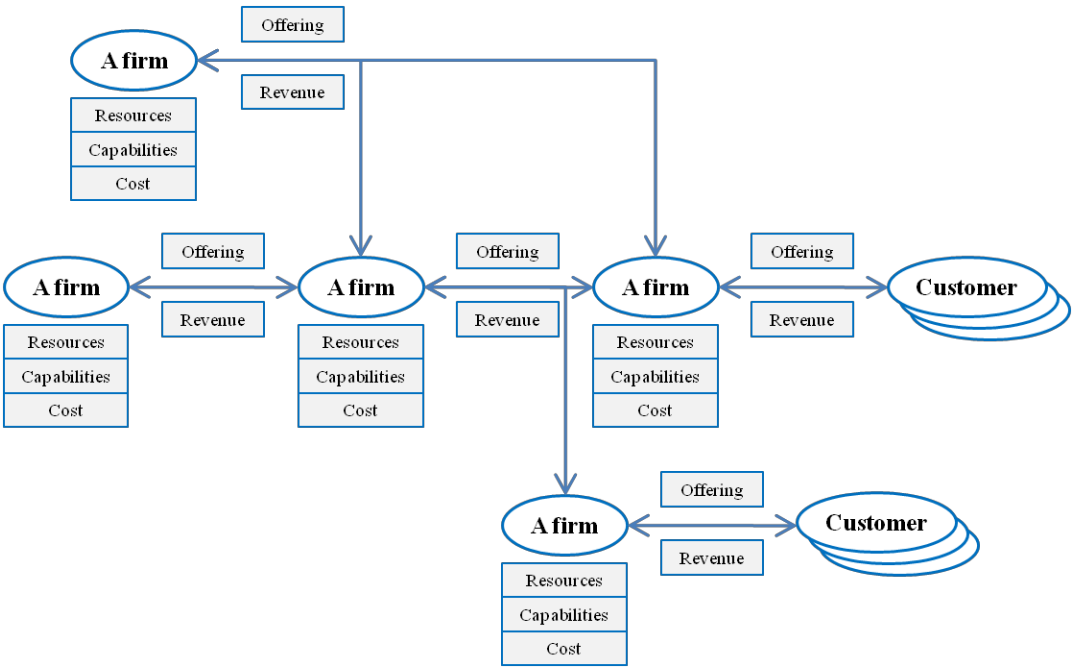

Figure 2: Theoretical view on business ecosystem based on actors' business models.

Ecosystem structure comes from vertically and horizontally interconnected members. In the case ecosystem, model is constructed from three key elements described in Table 2. These elements are *actors, offering* and *revenue*.

RESEARCH FRAME

Research context: Service business industry

Finnish service business industry grew 8,5 % at the last quarter of 2010 compared to fourth quarter of 2009. Year earlier the turnover decreased 7,7 %. (SVT 2010) Actors in service business can be divided in service requestors and service providers. These two categories are the fundamentals of a business system. Service requestors have a need for a specific service as service providers are intended to produce this particular service. However, requestors and providers mainly determine the relationship between two different actors and do not provide further information alone. Therefore different actors should be categorized further to describe their position and function in an ecosystem. In this case, actors are divided in to seven groups based on their role and offering in the system. Actors of this service business ecosystem are presented in Figure **3**.

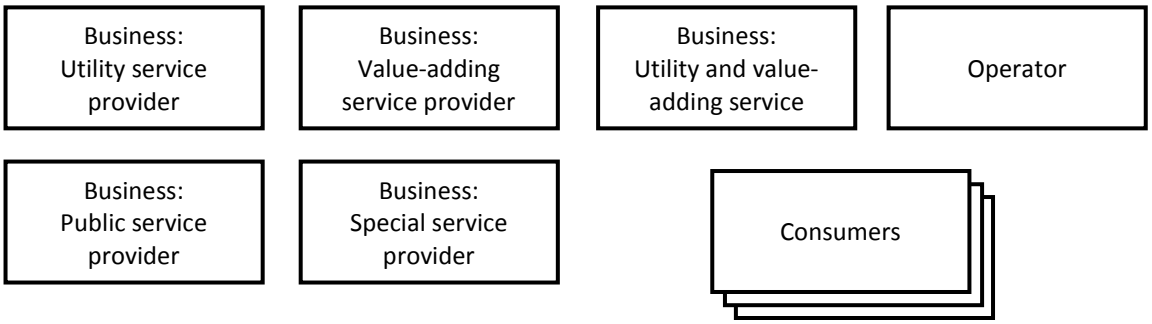

Figure 3: Main actor groups of service business ecosystem.

Consumers are the group which generates demand in the ecosystem. They are in the very end of a value chain while businesses are group which are generating supply to answer the demand. In contrast to groups mentioned above, operators are providing supply to consumers and businesses. In addition, operators can also channel demand and value between actors. Each actor in the case ecosystem is categorized to one of these groups introduced above. Furthermore, relationship between actors is modeled regarding two parts of their business models. This covers identifying their offerings and revenue streams to understand fundamentals of value capture and value creation functions. Case ecosystem is considered as a closed system. Thus actors outside this primary system are ignored although they would actually influence the ecosystem. Differences between actors are described in Table 3.

Table 3: Actors of service business ecosystem.

Actor	Description	Usage (frequency)	Customer relationship
Operator	Utility recource and service provider	Daily	Fixed
Utility service provider	Utility service procider with daily based transactions to customers. Offers services to both businesses and consumers	Daily	Fixed
Value-adding service provider	Value-adding service provider which offers monthly consumed services to customer	Monthly	Fixed
Public service provider	Provides monthly consumed public services to consumers	Monthly	Variable
Special service provider	Provides daily consumed services to a specific segment of consumers	Daily	Fixed
Utility and value-adding service provider	Provides both utility and value-adding services to consumers	Daily	Variable
Consumers	Group which generates demand in the ecosystem	N/A	N/A

To describe the case ecosystem, each actor were identified and categorized to one of the three categories mentioned above (business, operator and consumer). Actors in business category were further categorized according the classes described in Figure 3. Secondly, value creation, in terms of offering, is modeled qualitatively between actors. Then value

capture, in terms of revenue stream, was modeled. Finally, both value creation and capture were attached to combine a comprehensive model of the case ecosystem. The model was then analyzed qualitatively focusing on the number and nature of relationships between actors.

SERVICE BUSINESS ECOSYSTEM CASE DESCRIPTION

Service business ecosystem described in this paper consists of one operator, five types of businesses and one group of consumers which is assumed to be creating all the demand in the ecosystem. Business categories are categorized by industries. In addition, there are more than one businesses operating under categories *Value-adding service providers* and *Public service providers* while other business categories consists from only one actual business. Case business ecosystem is presented in Figure 4 below.

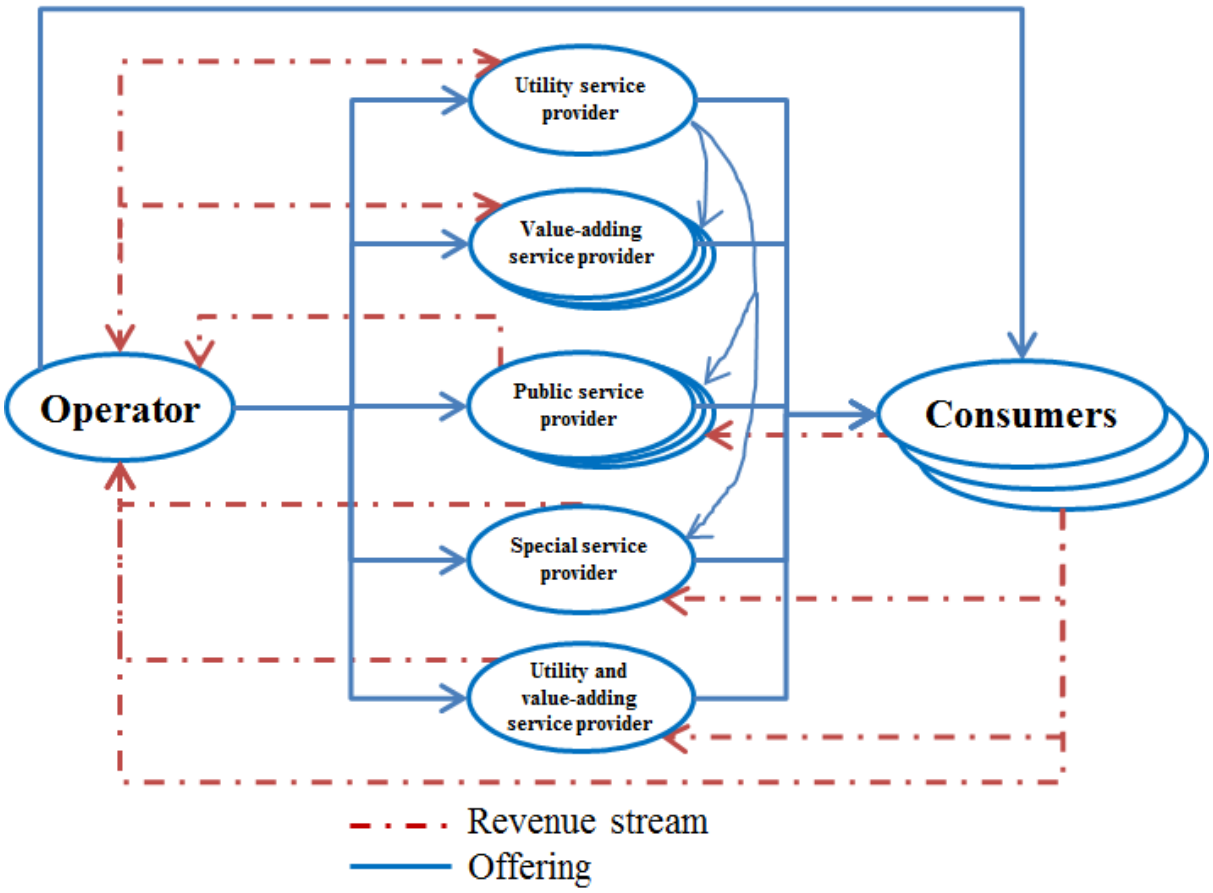

Figure 4: Service business case ecosystem.

As described in Figure 4, case business ecosystem consists of several actors, offerings and revenue streams. To raise the different roles of actors, relationships between each actor were tabulated in terms of offering and revenue stream. This data is presented in Tables 4 and 5. Moreover, offerings were categorized to resources and services. Resources indicate that receiver of created value are using the product of an offering in its own value creation process while other offerings are categorized to service category.

Table 4: Offerings between actors.

	Receiver of Created Value (Description)							
Actor	**Operator**	**Utility service provider**	**Value-adding service provider**	**Public service provider**	**Special service provider**	**Utility and value-adding service provide**	**Consumers**	**Connections in total**
Operator	N/A	(Resources)	(Resources)	(Resources)	(Resources)	(Resources)	(Services)	6
Utility service provider		N/A	(Services)	(Services)	(Services)		(Services)	4
Value-adding service provider			N/A				(Services)	1
Public service provider				N/A			(Services)	1
Special service provider					N/A		(Services)	1
Utility and value-adding service provider						N/A	(Services)	1
Consumers							N/A	0

In the case ecosystem, operator is offering resources to different businesses and this is explicit in a closed system as operator is the only supplier in this particular ecosystem. However, if the study would be extended, businesses would have other supply options. To maintain its special role, operator is offering resources below common market price, which generates a cost advantage to businesses of the case ecosystem. Operator has a cost advantage over direct competitors. Instead of just selling products with higher margin, operator is exploiting the cost advantage to gain extended control over value and revenue streams.

Table 5: Revenue streams between actors.

	Gains revenue from							
Actor	**Operator**	**Utility service provider**	**Value-adding service provider**	**Public service provider**	**Special service provider**	**Utility and value-adding service provide**	**Consumers**	**Connections in total**
Operator	N/A	1	1	1	1	1	1	6
Utility service provider	1	N/A						1
Value-adding service provider	1		N/A					1
Public service provider				N/A			1	1
Special service provider					N/A		1	1
Utility and value-adding service provider						N/A	1	1
Consumers							N/A	0

FINDINGS

To answer to the research question (*RQ: How can business models of actors be exploited in developing a new business ecosystem?*) research frame was developed and tested. Hence a case ecosystem was modeled. Even if the actual modeling didn't cover every single aspect of actors' business models, outcome provided an insightful map of an ecosystem. Therefore, business models of an ecosystem's actors can be exploited to model the value capture and value creation structures. Model can then be compared to competing ecosystems and an ecosystem under development can be elaborated to acquire competitive advantage over competing ecosystems.

In the case ecosystem, both *Operator* and *Utility service provider* are offering value to four to six different actors in the case ecosystem while other businesses are offering value to only one specific actor (Table 4). However, operator is the only actor which has more than one revenue stream (Table 5); operator gains revenue from every single member of the case ecosystem. Other actors besides the *Operator* and *Utility service provider* are focusing on a niche portion of the ecosystem. This phenomenon was also noticed by Corallo et al. (2007).

In addition, *Utility service provider* and *Value-adding service providers* are gaining revenue only from the operator even though they do not have direct offering towards operator. Therefore the actual cash flows are streaming from *Utility service provider's* and *Value-adding service providers'* customers to operator. Thus operator is completely controlling cash flows of *Utility service provider* and *Value-adding service provider*. For the operator to retain such a special role, it is crucial to have a competitive offering.

The case ecosystem modeled is not functioning as a closed system in practice. Each actor is competing with its competitors and the ecosystem is competing with other ecosystems. Key questions to ask when assessing the robustness of the case ecosystem are: 1) Why are the consumers staying in this ecosystem; 2) Why are businesses staying in this ecosystem; 3) How is the ecosystem worthwhile to the operator? What comes for the consumers, they prefer the ecosystem over competing systems because of cheaper services and value-added by operators administrative operations. Businesses, in the other hand, prefer the case ecosystem because they are gaining a cost advantage over direct competitors. And finally, operators extended control over the business ecosystem is just one technology of leveraging a cost advantage.

CONCLUSIONS

In the case ecosystem, operator is not operating in a monopoly in practice. Therefore, it's not obvious to operator to maintain control over cash flows and value creation processes. The key issues to retain its position, operator has to provide resources to businesses below market price. This is providing cost advantage to businesses of this specific ecosystem. Hypothetically, operator could dominate the ecosystem and suck all the profits from the system, but this is not feasible when competing with other ecosystem as the operator has to be able to provide more value to its co-actors than other ecosystems could.

Modeling technique developed is suitable for modeling and analyzing a business ecosystem. Mapping actors of the business ecosystem and describing their relationships will provide a model of an ecosystem. In addition to just modeling the value creation structure, approach taken in this paper covers the relationships between actors. This offers insights about roles of different actors. In particular, special roles, such as operator which controls every cash flow, should be elaborated. While developing a new business ecosystem, it's crucial to understand what is necessary for the ecosystem to succeed and compete against other systems.

This research mainly covered four relevant business model components which are actors, value creation structure, revenue and offering streams, but did not dig deeper on capabilities, resources and costs. In this study, operator was stated to be able to offer cost advantage to its customers via resources. This cost advantage, however, was not quantified. Therefore, this approach does not allow needed data to justify which ecosystem would be the most competent, if several ecosystems were modeled. To conclude, this approach developed and tested in this study provides a way to model business ecosystem by the business models of its actors, yet it does not provide data which could be used to analyze which business ecosystem would win over another.

Further research

Further research could be focused on analyzing other case ecosystems from service business industry to map different value creation structures. Furthermore, it could be interesting to study whether there is difference in success of ecosystems and what are the key issues which determine the success of an ecosystem. Do differently structured ecosystems perform differently in the market? Therefore, a hypothesis for further research could be set in the following way: *Competitiveness of an ecosystem is dependent from the structure of the ecosystem*. In addition, further research could focus on analyzing strategies of special players in an ecosystem. As in the case ecosystem, operator was in a special role, but is there other ways, than providing a cost advantage to customers via resources, to gain a special role in an ecosystem. Furthermore, is there other kind of special roles, than controlling the flows of value and cash?

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DECENTRALIZED BIO-CHP PLANT SUPPLIER CANDIDATES' COLLABORATION WITHIN THEIR BUSINESS NETWORKS

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ABSTRACT

Global warming is becoming a serious environmental concern, and current primary energy sources are also getting exhausted. Decentralized combined heat and power production using biofuels such as forest biomass could offer a qualified sustainable solution for many regions. The objective of this paper is to analyze what kind of heating plant manufacturers exist in the bioenergy field in Finland that also have future potential for supplying power generation units, and how they collaborate within their business networks. The primary sources of information for the industry evaluation were an analysis of major industry players based on financial and non-financial data and key expert interviews. The results reveal that the plant suppliers can be divided into three different clusters: network leaders, turnkey suppliers and distributors; and that they collaborate extensively within their business networks. The plant suppliers complement their own capabilities and competences by efficient networking that prepares the way for complete plant deliveries instead of component and parts supply only.

Keywords: Business networks; resources; capabilities; bioenergy technology; combined heat and power production

INTRODUCTION

The increased amount of greenhouse gases in the atmosphere has raised the Earth temperature, and Global warming is threatening to escalate to a serious environmental challenge. Increased use of renewable primary energy sources and improved overall energy efficiency play an important role in the future energy production and consumption. (Tekes, 2008) Decentralized (distributed) small scale combined heat and power production (CHP)

using biomasses, such as woodchips from logging residue, is also emerging as the technologies become more advanced and commercialized. At present, technologies for commercial heat and power production using various biomasses are mainly based on combustion technologies. (Kara et al., 2003) In particular, it is suitable for introducing novel production technologies utilizing forest biomasses in regions that have adequate natural resources enabling their sustainable exploitation. According to International Energy Agency (2011) biomass is a particularly lucrative primary energy source in countries where natural resources are abundant and conventional energy is expensive.

Firms operating in emerging industries, such as distributed bio-CHP generation, need various resources and competences, and they also need to collaborate with other players in order to develop the novel business environment. Firm resources, especially when they are valuable, rare, inimitable and non-substitutable, could provide sustainable competitive advantage, and thus enable the firm to find optimal product-market activities (e.g. Wernerfelt, 1984; Barney, 1991; Barney and Hesterly, 2006). However, many firms, including competitors, are sharing their resources and expertise to develop new products, achieve economies of scale, and gain access to new markets and technologies, because single firms often lack necessary resources. The go-it-alone strategy has changed into an alliance one. Strategic alliances can be either intra-industrial or inter-industrial and may include licensing, supplier relations, joint ventures, collaboration, R&D consortia, industry clusters, and innovation networks. (Trott, 2008; Doz and Hamel, 1998)

In spite of their growing importance, the Finnish manufacturers supplying distributed biofuel heating plants are still relatively unexplored. In order to fill this research gap, this paper strives to explore what kind of players and business networks operate within the group of plant manufacturers and suppliers that have future potential for also supplying power generation units. Thereby, the research question is: 'What kind of key players operate among biofuel heating plant manufacturers and suppliers in Finland, and how do they collaborate within their business networks?' Using financial data from national information provider's data sources and company literature from the firms' Internet home pages the paper analyses the key players within the business. The analysis is complemented by interviews of key industry informants in order to increase the understanding of the key players and their business networks. Finally, network analyses are conducted as a synthesis from the financial and non-financial data and the interviews.

The results reveal that the key players are small and medium size enterprises that deliver complete heating plants to end customers on turnkey basis including life cycle services, as well as parts and components of their own manufacture either to end customers or other manufacturers. The firms complement their own capabilities and competences by maintaining and developing diversified business networks that include suppliers, other manufacturers, competitors, universities, service providers and end customers. The firms can be divided into network leaders, turnkey suppliers and distributors. This paper contributes to providing evidence on firms complementing their competences by collaboration within their business networks. Knowledge about the key players, versatile network structures, and clusters in the industry have practical implications for the managers in the industry.

SMALL-SCALE COMBINED HEAT AND POWER GENERATION IN BIOENERGY

The principle of combined heat and power production (CHP), or cogeneration, has been known for quite a long time. Already in the beginning of the 20th century there were a number of units in operation. (Pehnt et al., 2006) According to WADE (2003) CHP is: 'The process of producing both electricity and usable thermal energy (heat and/or cooling) at high efficiency and near the point of use'. CHP thereby contains three focal elements: simultaneous heat and electricity production, high efficiency performance, and the proximity of energy production unit to customers. Today, several technologies capable of providing combined heat and power exist, especially in small scale, for example, reciprocating engines, gas turbines, Stirling engines, fuel cells, and thermophotovoltaics. Reciprocating engines already represent mature technology, whereas Stirling engines are just approaching commercialisation although the technological roots go back to the 19th century. The other technologies still have a few years until market introduction. (Pehnt et al., 2006) Further, Motiva (2010) adds that various technologies using different primary fuels are adequate for CHP production. Many technologies, however, still require significant R&D investments before they are feasible for viable commercialization.

At the moment, it is hard to predict which of the technologies will eventually attain new dominant design lock-in. According to Anderson and Tushman (1990) and Tushman (1997) technologies seem to undergo repeated cycles, and understanding the evolution of these cycles helps companies to predict the time of radical changes. Technological discontinuity generally leads to a single industry standard, a dominant design, which is then followed by a peak in sales and cease in innovation activity. (Anderson and Tushman, 1990; Tushman, 1997) The emergence of a dominant design is often the result of a combination of technological, economical and organizational factors, and thus it is not necessarily simply the most promising technological invention. However, when dominant design becomes the industry standard, it opens new possibilities to accelerate the adoption of a new design as dominant, for example: industry regulation and government intervention, strategic moves of firms, networking in the industry and possession of collateral assets. (Suarez and Utterback, 1995)

Compared to separate heat and power generation, decentralized CHP production provides several benefits, such as cost savings and lower emissions due to outstanding efficiency, as well as increased security, power quality and grid reinforcement due to on-site location. For example, fuel consumption could be about one third lower than in separate heat and power generation. (Combined Heat and Power Association, 2010; Ahtila et al., 2005) Small scale combined heat and power production could form a supplementary building block for a more sustainable future energy system in many countries. The economical and ecological performance of small scale CHP varies by technology and strongly depends on the implementation context. All in all, regulations and institutional frameworks play a crucial role in the development and diffusion of small scale bio CHP technologies. (Pehnt et al., 2006)

FIRM CAPABILITIES AND BUSINESS NETWORKS

Firm resources, especially when they are valuable, rare, inimitable and non-substitutable, i.e. when they fulfill the VRIN-conditions, tend to provide sustainable competitive advantage, and thus enable a firm to find optimal product-market activities (Wernerfelt, 1984; Barney, 1991; Barney and Hesterly, 2006; Bowman and Ambrosini, 2003; Johnson et al., 2006). Firms' competences are based on various resources that can be regarded as building blocks of enterprise capabilities and competencies. Core competences are a unique collection of competences that cross strategic business unit boundaries, are widespread in the firm, and are formed from the collective learning of the organization. Core competences provide access to a variety of potential markets, they contribute significantly to customer satisfaction and the company's end products, and they are difficult for others to recognize and imitate. Core competences are also rare, and typically even diversified corporations have only a few fundamental core competences. A company's long term competitiveness derives from systematically built core competences and company strategies and competences are also strongly interrelated. (Prahalad and Hamel, 1990; Javidan, 1998) It is vital for companies to integrate both company strategies and core competences. As a conclusion, companies should efficiently integrate their overall business strategy, core competences and key technologies. (Torkkeli and Tuominen, 2002)

The radical geopolitical and economical changes during the past decades have meant that company and industry boundaries have blurred and firms' legal boundaries differ considerably from their strategic boundaries. As a matter of fact, firms can achieve new innovations, growth and competitive advantage by cooperating with others in value networks (e.g. Parolini, 1999; Möller et al., 2004; Lipasti, 2007) Through collaboration and strategic alliances within a firm's external value network a firm can gain access to required capabilities by linking its own resources to partners' complementary ones, and thus achieve a sustainable competitive advantage (Barney and Hesterly, 2006; Johnson et al., 2006; Chen and Chen, 2003; Crain and Abraham, 2008). Today, a firm's supply chain (network) extends both upstream and downstream of the value chain integrating firm's suppliers, other manufacturers, service providers and customers. The ultimate objective of the value chain is to achieve a sustainable competitive advantage for the firms within the network, and furthermore, market competition takes places between supply chains rather than between single firms. (e.g. Xu, 2011; Jayaram et al., 2011; Liu and Zhang, 2011) In addition, a broad understanding exists about the significance of business networks for emerging firms and small and medium size firms (SME). Business networks are beneficial particularly for SMEs, since they are thus able to efficiently acquire resources they lack, and focus on their own core competences. (e.g. Hite and Hesterly, 2001; Fuller-Love and Thomas, 2004; O'Regan and Kling, 2011)

RESEARCH DESIGN AND DATA

The empirical study was executed as a case study. As a matter of fact, according to Eisenhardt (1989) a case study is not a methodology, but rather a research strategy that concentrates on increasing the understanding of present dynamics within a single setting. Case studies also typically combine diverse data collection methods, such as interviews,

questionnaires, observations and archives. Yin (2003) agrees with this and defines a case study a research strategy that investigates a contemporary phenomenon within its real world context. Creswell (2007) determines a case study as an exploration of a bounded system that can be defined in terms of time and place, and through detailed, in-depth data collection, involving multiple rich sources of information. The network analyses of the firms were based on financial data, literature review and interviews which were conducted in order to answer the research question: 'What kind of key players operate among the biofuel heating plant manufacturers and suppliers in Finland, and how do they collaborate within their business networks?'

The primary source for acquiring the list of companies was a trade magazine (BioEnergia, 2010), and the list was further augmented by experts' knowledge. There are, for the moment, fewer than 40 key players in the field in Finland, and 26 of them agreed to participate in the interview. These 26 firms were also included in the financial analysis. The firms' financial data was collected from a national information provider (Fonecta, 2010) whose data base includes financial data of approximately 100 000 national companies including publicly listed companies as well as privately owned small and medium size enterprises (SME). The financial data based on the financial statements of the firms included their revenue, net income, return on invested capital (ROIC), equity and quick ratio for the years 2005-2009. Based on Leppiniemi and Kykkänen (2007) while evaluating the firms' financial performance ROIC was regarded good if it was over 15 % and satisfactory if it was below 15 %. Negative ROIC was evaluated weak. Accordingly, over 40 % equity ratio was regarded good, 20 to 40 % satisfactory and below 20 % weak. Quick ratio over 1 was rated good, 0.5 to 1 satisfactory and below 0.5 weak.

The quantitative analysis was complemented with a literature review of the firms based on their Internet home pages, and with interviews with 26 key informants. The interview sessions were conducted in May and June 2010 by two researchers, the interviews were audio recorded and results were crosschecked by two other researchers. The interviewees were composed of top management and company experts including 15 CEOs and three other top executives. The key informants were interviewed using a semi-structured theme questionnaire concentrating on two main issue areas: (1) Firm related issues: background information such as market review, offered products and services, key technologies, CHP potential, human resources, competences, product modularity, exports; and (2) Network related issues: general network structure, network participants, network performance, customer orientation, network benefits to R&D. The network analyses are a synthesis from the firms' financial analysis, the literature review, and the interviews.

EMPIRICAL ANALYSES

The firms could be categorized into three clusters: (1) network leaders, (2) turnkey suppliers, and (3) distributors. Network leaders are larger firms in terms of revenue, balance sheet and number of personnel and thus their resources were estimated more significant than those of other firms. The majority of the network leaders also manufacture their core products in-house or own product-rights. Similarly, turnkey suppliers produce a part of their

products in their facilities or own the product-rights but their capabilities are lesser than those of the network leaders. Distributors mostly import their product range.

Financial analyses of the firms

The analysis included altogether 26 firms, for 19 of which financial data from the national data bank (Fonecta, 2010) was available. Financial statements of the firms were analysed from the years 2005-2009, and the firms that had financial data available for less than three years were ignored in the analysis. The results reveal that the average revenue of all the firms was 6.263 M€, the average revenue of the network leaders was 13.356 M€, the turnkey suppliers' 2.702 M€, and the distributors' 0.395 M€. The network leaders had the largest net income of 0.577 M€, (4.3 % of revenue), and the turnkey suppliers' net income of 0.173 M€ (6.4 %) was comparatively the best one. The distributors had a slightly negative net income. The return on invested capital (ROIC) was on good level in all the groups. The average equity ratio was on satisfactory level for all the company categories, whereas the average quick ratio was on good level. Generally, standard deviation (STDEV) in most of the studied factors and company groups was rather high revealing that the firms within the groups were relatively heterogeneous. All in all, the network leaders were medium size companies, the turnkey suppliers were small, and the distributors were micro companies. The good ROIC within all the groups could be a consequence of relatively good financial results and modest capital investments. The equity ratios of the firms give support to the modest capital investments. The good quick ratios of the firms reveal a generally healthy liquidity of the firms. Table 1 summarizes the comparisons of financial performance between the firms.

Table 1 : Comparison between clusters.

	All Firms	Network Leaders	Turnkey Suppliers	Distributors
Revenue				
average, t€	**6263**	**13356**	**2702**	**395**
(STDEV)	**(9366)**	**(12549)**	**(2827)**	**(390)**
Net Income				
average, t€ (%)	**289 (4.6 %)**	**577 (4.3 %)**	**173 (6.4 %)**	**-38 (neg.)**
(STDEV)	**(562)**	**(840)**	**(227)**	**(115)**
ROIC				
average, %	**30.5**	**23.9**	**37.2**	**26**
(STDEV)	**(28.4)**	**(23.5)**	**(30.2)**	**(39.7)**
Equity				
average, %	**31.6**	**22.9**	**39.8**	**27.3**
(STDEV)	**(22)**	**(13.9)**	**(27.4)**	**(14.2)**
Quick Ratio				
average	**1.52**	**1.06**	**1.70**	**2.06**
(STDEV)	**(1.16)**	**(0.31)**	**(1.57)**	**(0.75)**

Interviews

The main portion of the heating suppliers' turnover consisted of domestic sales. The interviewed experts shared the view that increase in export activity is in reality the only possibility to increase company business in a sustainable fashion. The Scandinavian countries, Russia, the Baltic countries and Eastern Europe were regarded as the most promising export countries in the short term. Generally, the interviewees did not consider foreign competitors as a serious threat at the moment, since they estimated their own firm's competences higher than those of foreign competitors. The experts also estimated that customers would value e.g. warranties given by domestic firms and local maintenance services higher than those provided by foreign companies. The product assortment of the heating plant suppliers was very extensive; the plant capacity scale varied from 20 kW to 100 MW, although the typical nominal capacity of the plants was between one and two MW. Woodchips was the most common biofuel for all plants, and nine interviewees mentioned that their plant could use peat in addition to woodchips, and six plants were also able to use oil. Some plants could also use reed canary grass or grain as their biofuel.

The interviewees evaluated their firm's core competences quite differently; some mentioned just a single technology, while others specified a broader context as their competence. Ten firms named combustion technology as their core competence, three named boiler technology, and three modularity related issues. Four firms valued turnkey deliveries as their core competence, four value creating customer solutions, and two network relationships. According to the key informants, small scale CHP technology interest most of the firms. However, technological solutions are still in the emergent phase, and most of the firms would prefer to collaborate rather than to execute challenging R&D on their own. Political decisions and e.g. various investment subsidies and electricity feed-in tariffs play an important role in decision making processes.

Typically, most of the firms manufacture parts and components for the plants, such as boilers, conveyors, automation or firing (combustion) technology based on their capabilities and competences, or the product-rights belong to the firm and the parts may be outsourced. Heating plant building, construction, electrification and plumbing are typically acquired locally. However, end customers usually appreciate turnkey deliveries of the plants, and thus the plant suppliers have to collaborate with their sub-suppliers, service partners, universities, other manufacturers and even competitors in order to fulfill customer requirements.

The key informants shed light on the versatile business networks that the plant manufacturers have developed and maintain. To exemplify, a simplified business network among a part of the key players is illustrated in figure 1. For the sake of clarity, customer, sub-supplier, and service partner networks are omitted, and manufacturers' (M1; M2; etc) key technologies and focal own production activities are indicated in the figure by solid line ovals, whereas outsourced key activities and production are indicated by dashed line ovals. For example, Manufacturer number one's (M1) combustion technology is produced in-house, whereas automation is outsourced. In addition, M1 has intense relationships with manufacturers M2 and M13. In comparison, manufacturer M26 is independent from other

plant suppliers, and its in-house produced key technology is boiler technology, whereas plant implementation is outsourced. All in all, the plant manufacturers complement their own capabilities by efficiently exploiting their business networks including customers, subcontractors, other manufacturers, competitors, various service providers, and institutions such as universities. This kind of business strategy provides them for supplying turnkey deliveries to end customers instead of component supply only. A more in-depth network analysis is conducted in the following section.

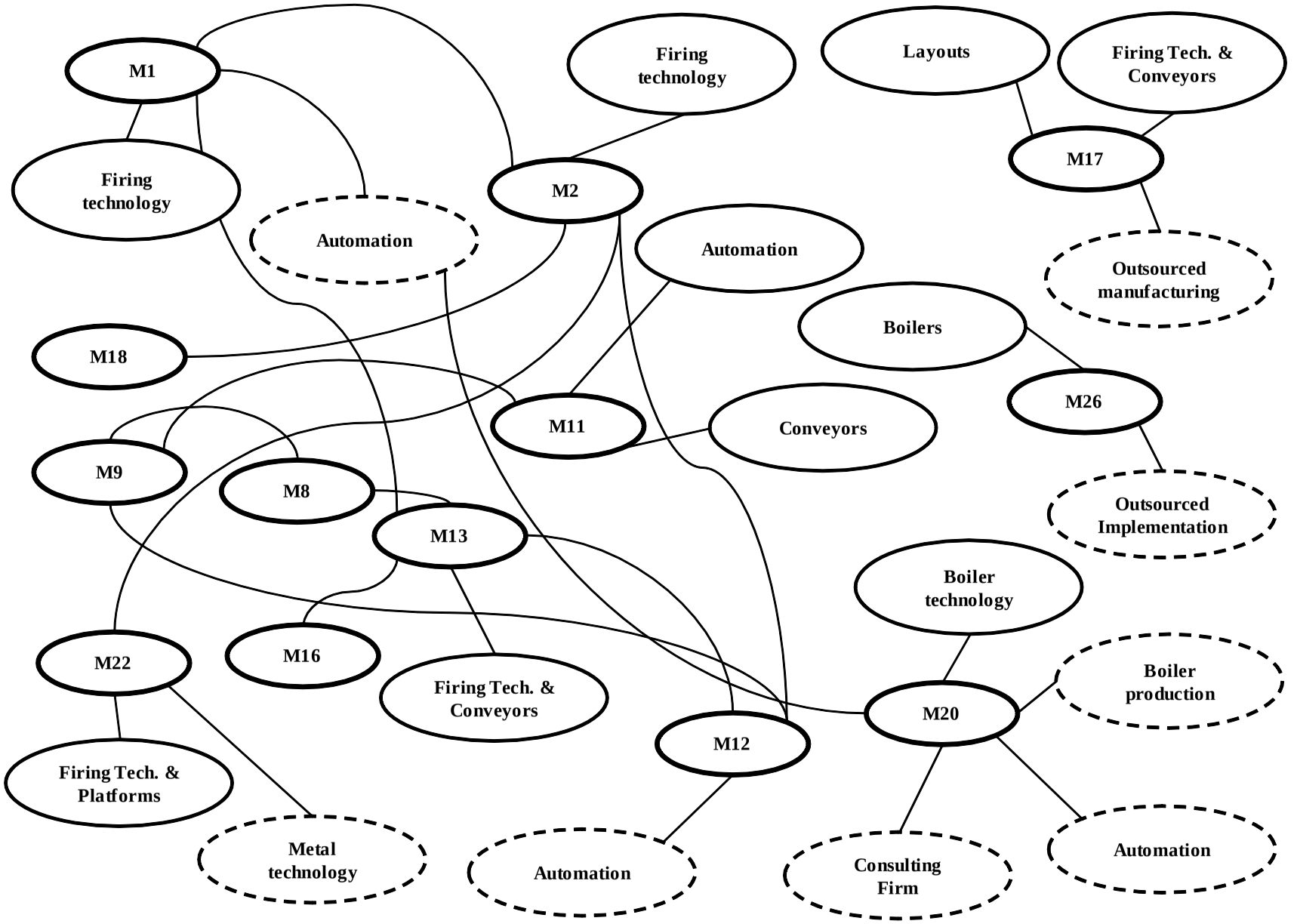

Figure 1 : Typical heating plant manufacturers' network structures.

Network analysis

Instead of making an attempt to investigate the often hidden company core competences, firms' overall capabilities were analysed by evaluating their human and physical resources, financial performance, export activities, as well as accumulated experience and know-how. Correspondingly, firms' network activities were analysed by evaluating their overall network performance, customer orientation, and network benefits to R&D. The evaluation of the different factors was based on the interviews supported by firms' data e.g. from their Internet home pages when applicable. The evaluation of financial performance was based on the financial statements of the companies, and the evaluation of the physical resources of the firms was based on actual observation of the researchers on site. Financial data was available for 19 firms, and researchers could observe 22 firms' physical resources on site. The individual factors were scored by numbers one to five so that the best value of the factor was five, the average value among the firms three and the worst value one. For example, if a firm had significant exports to several countries the value was five, and if it had very little or no exports at all the value was one. An average export activity within the firms justified the value three. Equally, if e.g. a firm's network exploitation and benefits to its R&D were significant the value was five, whereas if a firm's R&D was mostly performed in-house without any experienced network benefits the value was one. Other factors were evaluated similarly. The evaluation was executed individually by two researchers, and the results were crosschecked by two other researchers.

Finally, the firm's points for human resources, physical resources, and exports were weighted by a factor 2, whereas financial performance and experience / know-how were weighted by a factor 1. Equally, overall network performance and network benefits to R&D were weighted by a factor 2, whereas customer orientation was weighted by a factor 1. The motivation behind that reasoning was that firstly, financial data was available for only 19 firms, and the worldwide recession that hit industry and commerce in 2008-2009 may have significantly influenced these financial figures. Secondly, firms may have evaluated experience / know-how equally, but in case the capability depends merely on a few individuals, it may prove to be highly vulnerable. Thirdly, firm representatives typically tend to argue that their firm is customer oriented. Thereby, this kind of weighting in the evaluation gives higher importance to the most solid factors while at the same time balancing the influence of the factors that may carry some uncertainties. General directions for evaluation were as follows:

- Human resources (a): the number and education of employees in relation to firm's overall size
- Physical resources (b): firm's plant and machinery
- Financial performance (c): financial factors from firm's financial statements
- Exports (d): volume of exports and number of export countries
- Experience and know-how (e): background, history, and experience in heating plant supplies

- Overall firm capabilities: average outcome of (a+b+c+d+e)
- Overall network performance (f): number and nature of network partners, and network functionality
- Customer orientation (g): scope and functionality of customer relationships, partnerships
- Network benefits to R&D (h): exploitation and functionality of network for company R&D
- Network activity: average outcome of (f+g+h)

The network leaders' average score for overall firm capabilities is 6.54, the turnkey suppliers' average score is 4.21, whereas the distributors' score is 2.77. The network leaders have overwhelming capabilities compared to the other clusters, and the distributors evidently have the least capabilities. Table 2 summarizes the firms' overall capabilities.

Table 2 : Firms' overall capabilities.

	Human Resources a)	**Physical Resources b)**	**Financial Performance c)**	**Exports d)**	**Experience/ Know-how e)**	**Overall Firm Capabilities (Average a+b+c+d+e)**
Weighting	**2**	**2**	**1**	**2**	**1**	
Network Leaders, average score (STDEV)	**7.75 (1.98)**	**8.25 (1.67)**	**4 (1)**	**8.25 (2.49)**	**4.13 (0.64)**	**6.54 (1.24)**
Turnkey Suppliers, average score (STDEV)	**5.23 (1.01)**	**5.78 (2.11)**	**4.22 (1.09)**	**3.23 (2.09)**	**3.31 (0.86)**	**4.21 (1.02)**
Distributors, average score (STDEV)	**3.6 (1.67)**	**2.4 (0.89)**	**3 (1.73)**	**3.2 (2.68)**	**1.8 (0.45)**	**2.77 (0.73)**

Firms' network activities were estimated in a similar manner, and are summarized in table 3. The network leaders' average score for network activity is 4.88, the turnkey suppliers' average score is 4.69, and the distributors' is 3.4. Both the network leaders and turnkey suppliers exploit their business network to a similar extent. The distributors collaborate the least within their business network. The firms sell either turnkey plant deliveries to end customers, or components to other manufacturers, competitors and customers. This configuration has lead to a versatile network within various component suppliers, service providers, competitors and end customers. The network leaders and turnkey suppliers

operate actively in their business network, whereas the distributors link their local customers and foreign component suppliers.

Table 3 : Firms' network activities.

	Overall Network Performance f)	Customer Orientation g)	Network Benefits to R&D h)	Network Activity (average f+g+h)
Weighting	**2**	**1**	**2**	
Network Leaders,				
average score	**6.5**	**3.13**	**5**	**4.88**
(STDEV)	**(2.33)**	**(0.99)**	**(2.83)**	**(1.39)**
Turnkey Suppliers,				
average score	**6.31**	**3.46**	**4.31**	**4.69**
(STDEV)	**(1.97)**	**(1.20)**	**(2.56)**	**(1.66)**
Distributors,				
average score	**5.2**	**1.8**	**3.2**	**3.4**
(STDEV)	**(1.79)**	**(0.84)**	**(1.10)**	**(0.64)**

When the single firm's capabilities and network activities are located into a matrix (see figure 2), it is highly evident that the network leaders have the most extensive capabilities, the turnkey suppliers have lesser capabilities, and the distributors have the least capabilities. On average, the network leaders and the turnkey suppliers tend to utilize their business networks equally, whereas the distributors operate more independently. In spite of their overwhelming resources and capabilities, the network leaders actively exploit their networks. The reasoning is that their strategy is to focus on their core competences and core products and outsource other parts of the plant deliveries. The distributors act as a liaison between their end customers and the foreign component and plant suppliers that they represent. However, as the relatively high standard deviations reveal, single firms exploit their networks quite differently, which becomes especially evident while examining the turnkey suppliers' network activities. It can be concluded that single firms complement their inadequate resources and capabilities by exploiting their business network actively, whereas other firms are more independent, and tend to develop and manufacture more or less everything in-house based on their strategy and resources. The different clusters' capabilities and network activities are illustrated in figure 2.

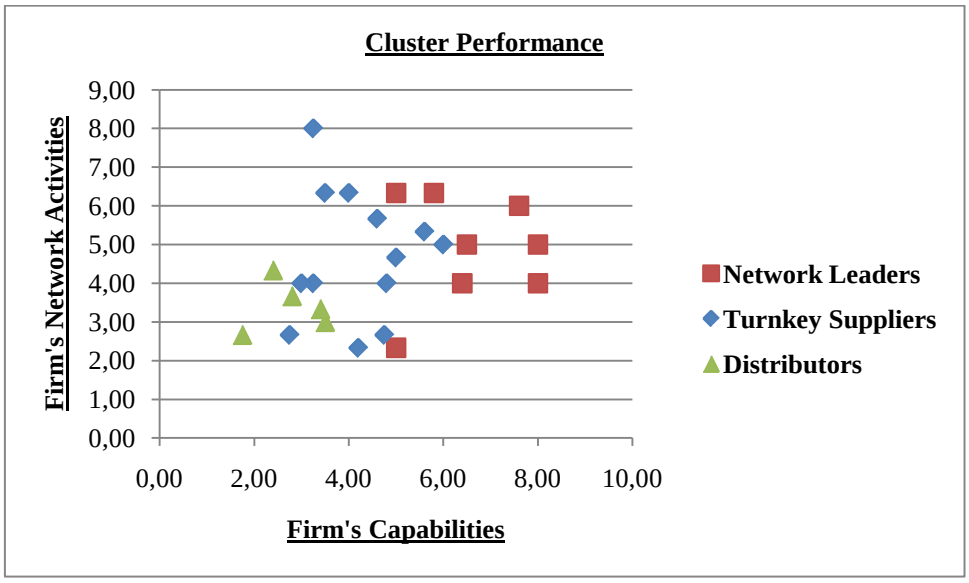

Figure 2 : Firm Capabilities vs. Network Activities of the Clusters.

CONCLUSIONS

Global warming is a rapidly growing environmental concern, and the current primary energy sources are also becoming exhausted. Increasing use of renewable energy sources has an ever growing importance for the future sustainable energy policy, and decentralized small scale CHP production using biofuels could provide a qualified solution for the environmental issue in many countries. The study increased understanding about the key heating plant manufacturers and suppliers in Finland that are also capable of providing power generation in their product portfolio in the future. The plant manufacturers produce their offering based on firm specific capabilities, competences and strategy, and they complement their competences by diversified business networks. Both the network leaders and the turnkey suppliers actively exploit their business networks. This enables them to satisfy end customer requirements, and to supply complete plant deliveries on turnkey basis instead of merely supplying components and parts. The distributors mostly operate as liaisons between their end customers and overseas plant and component manufacturers. The variation in network activity between single firms is relatively high in all the clusters revealing different strategies and capabilities of the firms.

This study contributes to providing evidence that firms complement their resources, capabilities and competences by collaborating within their business networks. The study also increased general understanding about the key players, networks, and clusters in the industry that can be considered as valuable knowledge for practical managers. The sample of the firms can be considered extensive, the interviewees were mostly top executives and company experts, and the results of the study were executed by two researchers and crosschecked by two others in order to ensure validity and reliability. The results of the study can also presumably be generalized to many other regions. The main limitations of the study are the to some extend limited financial data, and the potential influence of the global recession in 2008-2009 on the firms' financial figures. Bioenergy industry is rapidly

emerging, and it might be valuable to study in the future what kind of product modularity issues and business networks prevail in commercializing small scale CHP plants internationally.

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PARTNER SELECTION AND COLLABORATIVE RELATIONSHIP IN THE COLLABORATIVE COMMERCE

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ABSTRACT

Partner selection is a critical issue for the collaborative commerce (c-commerce) because it concerns the performance of a collaborative project. This study investigates the role of partner selection that may influence the collaborative performance via the collaborative relationship. After reviewing the related literature, a theoretical model was developed. This model includes the general partner selection factors of resource complementarity, organizational compatibility, trust and commitment and the c-commerce specific factor of information technology (IT) capability. For the collaborative relationship, this model takes into consideration of the two dimensions of the continuance and tightness within the partner relationship. The study conducted questionnaire survey to validate the proposed model and research hypotheses. The data collected from 103 Taiwanese enterprises that engage in c-commerce was analyzed and the research hypotheses are all supported. The study results show that the proposed five factors for c-commerce partner selection have influences on the collaborative performance through the collaborative relationship. This study contributes to revealing the mediating effect of collaborative relationship on the c-commerce partner selection and performance. The research findings may also serve as guidelines for collaborative partners to enhance relationship and performance in practice.

Keywords: collaborative commerce (c-commerce), partner selection, relationship, performance.

INTRODUCTION

An enterprise must constantly transform and upgrade to increase its competitiveness in the market and must extend its philosophy from single business entity to strategic alliance in order to survive the challenge of globalization. As a result, in addition to focusing on the development of core capability, collaboration becomes a critical strategy for modern enterprises. Collaborative commerce (c-commerce) is a win-win business model that integrates the needs of the suppliers, customers and partners through the Internet and mutually shares information and operation procedures with other entities [50]. Establishing a sound partnership through c-commerce allows an enterprise to rapidly respond to the needs of the market and enhance the competitive advantage of the entire value chain through information exchange, technical cooperation and resource integration with collaborative partners.

While c-commerce may bring a business synergy and interest, some companies often ignore the potential obstacles and risks associated with the partnership when implementing such an application. Change of organization structure, increased complexity, mutual trust and dependency and conflict management, for examples, can affect the development and maintenance of the partnership. Kanter [36] finds that some partnerships have existed more than 20 years and some others collapsed shortly after. A corporate strategic alliance has a chance of failure as high as 70% [26], and choosing the wrong partner accounts for 50% of it [21].

C-commerce is an electronic application of a corporate strategic alliance; partners must be chosen with discretion, compatibility must be considered, and reciprocal advantages must be taken into account. However, choosing the good partner does not necessarily guarantee good collaborative performance, and this study aims to fill the theory gap by investigating the role that partner selection plays in influencing the performance of c-commerce. In addition to an electronic application, c-commerce by nature is a partner relationship that may determine the result of resource integration among the partners. This study believes the collaborative relationship (or partnership of the c-commerce) has a mediating function in the process in which the partner selection influences the collaborative performance. The purpose of this study is to identify the role of collaborative relationship amidst the influence of partner selection on the collaborative performance. After reviewing the related literature, a research model will be proposed to explain how partner selection influences collaborative performance through collaborative relationship; and the model with its derived hypotheses will then be empirically validated using the data collected through a mail questionnaire survey.

LITERATURE REVIEW

Collaborative relationship

The popularity of the Internet allows collaboration to expand from within a corporation to inter-organizational relationship enabling effective communication and resource sharing for increased revenue, reduced cost, and competitive advantage. C-commerce is a model that allows the employee, business partners and customers to cooperate dynamically in a trade community or market [7]; with such model an enterprise may create greater business values by integrating its partners' resources via the Internet [19,42].

Business partners work together for the agreed objectives in c-commerce. The collaborative relationship brings benefits such as improved utilization of resources, shortened process time and reduced operation cost through information sharing, knowledge exchange and process integration [44,50]. For c-commerce to work more effectively an enterprise must pay attention to the forming and developing of partnership; a long term collaborative relationship may further promotes the success of the collaboration [43]. Successful partnership usually has high involvement in decision making and problem solving [38,44], and has features like high commitment, low conflict, effective conflict resolution, high cooperation and high trust [8,44,50].

Relationship refers to social connections based on mutual interests and benefits [31]. The partners in a collaborative relationship cooperate with one another for the common objectives, of which accomplishment requires sharing resources and risks. In such a mutually dependent relationship, business partners need to develop an effective collaboration pattern from the interaction with one another, which is a learning process that takes time to adapt to. Therefore an effective collaborative relationship must have a partnership continuance [5,27] and partnership tightness [15,22], and such a relationship will deliver a better collaborative performance [16,47]. Because the performance of c-commerce involves different prospects among the partners, it is difficult to measure objectively. The frequently used subjective indicators include project satisfaction and goal attainment [25,51].

Partner selection

Huang [29] believed that partner selection is the most important step in the forming of a strategic alliance. Choosing the right partner is critical to a sound and effective partnership. When choosing partners an enterprise must consider many factors. For a joint-venture, partner selection must consider the industry characteristics, firm capability, resource complementarity between the partner and the company, and organization compatibility [24]. For a collaboration partner, the factors have to be taken into consideration include the complementarity of advantages and capability, partner commitment, status similarity [10], social capital, goal compatibility, interdependency [13], task coordination, culture

compatibility [52], value and belief [54].

Though until recently there is not yet a consensus about the criteria for partner selection, the commonly used criteria found in the related literatures include resource complementarity, organization compatibility, commitment, trust, financial status, past experience and size difference [3,10,13,24,29,52,54]. Among these factors of partner selection, this study considers only four of them because c-commerce integrates mainly the technical and procedural resources of collaborative partners: resource complementarity, organization compatibility, commitment and trust. In addition, c-commerce adopts information technology (IT) to establish an electronic platform for the collaboration [7,19]; therefore this study also includes IT capability in the criteria for partner selection.

RESEARCH MODEL AND HYPOTHESES

This study concerns primarily about the influence of partner selection on the effectiveness of the collaborative relationship when an enterprise implements the c-commerce application. According to the above literature review, the criteria for selecting collaborative partners include resource complementarity, organization compatibility, commitment, trust, and IT capability. The collaborative relationship is divided into relationship continuance and relationship tightness, and such a collaborative relationship can affect the collaborative performance as shown in Figure 1. Relationship continuance means the partnership of the c-commerce should be long-term and the collaborative partners are willing to give up short-term interest in exchange for long-term cooperative advantages. Relationship tightness denotes that collaborative partners work together for the common objectives with sound interactions and value the interdependency between one another. Collaborative performance refers to the degree of satisfaction and goal attainment of a collaboration project.

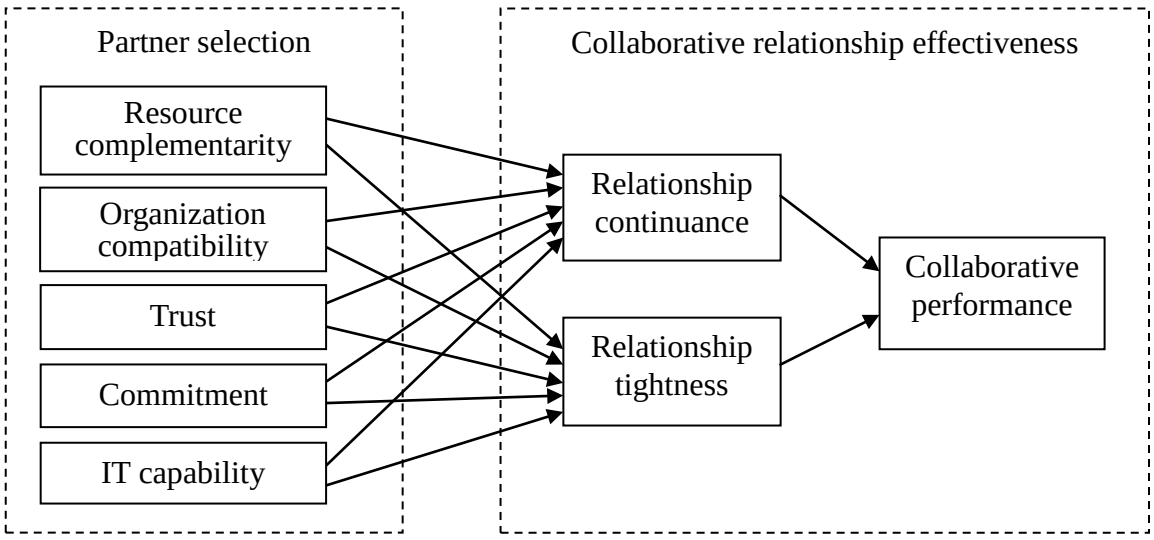

Figure 1: Research model.

Resource complementarity indicates a collaborative partner is able to provide valuable resources needed by the other and such resources are helpful to the accomplishment of the collaborative objectives [10,13,34]. Complementary resources can enhance the partner enterprises' business values and further promote the willingness of the engaged parties to strengthen the relationship [52]. Resource complementarity between partners implies the possibility of the potentially high development of the collaborative relationship; not only it may strengthen the attitudes of both partners toward the continuance of the long-term relationship, but also promotes the tight interaction between the partners [22,33]. Therefore, this study proposes the first set of hypothesis:

H1a: Resource complementarity between the collaborative partners is positively correlated to their relationship continuance
H1b: Resource complementarity between the collaborative partners is positively correlated to their relationship tightness

Organization compatibility is the similarities in terms of organization cultures, business models and strategic goals between the collaborative partners. Smaller difference in organization cultures makes it easier for the partners to communicate and may benefit the development of the collaborative relationship [28,48]. Similar business models and strategic goals between the partners may benefit the resource integration and tight cooperation between the partners [6,50]. Therefore this study proposes another set of hypothesis:

H2a: Organization compatibility between the collaborative partners is positively correlated to their relationship continuance
H2b: Organization compatibility between the collaborative partners is positively correlated to their relationship tightness

Trust means the collaborative partners have reliable professional knowledge and resource and will consider the best interest for one another [32]. Mutual trust between the partners enables resource sharing and the development of a tight collaborative relationship. Trust may reduce coordination cost, opportunistic behaviors and conflict and benefit the maintenance of a stable collaborative relationship [4]. Therefore this study proposes the third set of hypothesis:

H3a: Trust between the collaborative partners is positively correlated to their relationship continuance
H3b: Trust between the collaborative partners is positively correlated to their relationship tightness

Commitment means an enterprise believes its relationship with its partner is important and is willing to maintain such a valuable relationship with its best efforts [48]. Commitment

between the collaborative partners leads to the willingness on both sides to dedicate more investments, which implies a tighter and longer relationship [40]. Therefore this study proposes the next set of hypothesis:

H4a: Mutual commitment between the collaborative partners is positively correlated to their relationship continuance
H4b: Mutual commitment between the collaborative partners is positively correlated to their relationship tightness

Effective application of IT not only can reduce the transaction cost between the collaborative partners, but also promote the information sharing and process integration that contribute to a tighter relationship between the partners [11]. The implementation of a c-commerce application concerns with the IT capability, and the IT capability of a collaborative partner can affect the performance of the collaborative operation and the development of the partnership [37,42]. Therefore this study proposes the fifth set of hypothesis:

H5a: IT capability of the collaborative partners is positively correlated to their relationship continuance
H5b: IT capability of the collaborative partner is positively correlated to their relationship tightness

Once a continuing collaborative relationship is established, the cooperation between partners will be easier and the performance will be better. In a supply chain collaboration, for example, the buyer may know better about the supplier's capability and may acquire better product supply. On the other hand, the supplier may receive resource assistance from the buyer to reduce cost, improve quality and increase output [17,35]. C-commerce primarily concerns with the integration of related resources of the partners to accomplish the project together. A tight collaborative relationship makes the resource integration between the partners easier and the project execution more effective, and therefore the collaborative performance will be better [22,41,47]. Finally this study proposes two more hypotheses:

H6: Relationship continuance is positively correlated to the collaborative performance
H7: Relationship tightness is positively correlated to the collaborative performance

METHODOLOGY

This study investigates the role of collaborative relationship in the influence of partner selection on the collaborative performance. The proposed research model and hypotheses will be validated on the data collected through a mailed questionnaire survey. The survey was conducted to the companies with c-commerce experience in Taiwan. Visual PLS 1.04 and SPSS 17.0 are used for the data analysis, which includes descriptive statistic,

non-response bias analysis, measurement model and structural model analyses.

Measures

The items used in the survey instrument of this study were adapted from the scales developed in prior researches. The primary constructs include partner selection, collaborative relationship and collaborative performance. The factors for partner selection include resource complementarity, organization compatibility, commitment, trust and IT capability. Resource complementarity, which is the level to which a partner provides valuable and matching resource for the other partner, includes three items [2]. Organization compatibility, which measures the similarity among corporate cultures, business models and strategic goals of the partners, consists of three items [17,48]. Trust, which means the collaborative partners have reliable professional knowledge and resource and will consider the best interest for each other, comprises three items [16,23]. Commitment, which indicates that an enterprise believes its relationships with its partners are important and is willing to maintain such valuable relationships with its best efforts, contains three items [1,14]. IT capability, which measures the IT infrastructure and IT human resource, includes three items [53].

Collaborative relationship is divided into relationship continuance and relationship tightness. Relationship continuance, which means the partners believe the relationship with the other partner is important and expect to continue the current collaboration, comprises three items [14]. Relationship tightness, which measures the degrees of activity connection, resource integration and member interaction between the partners, includes three items [5, 9,18]. As for collaborative performance, which measures the degrees of satisfaction and goal attainment of a collaboration project, it consists of three items [25,51].

Each of the above-mentioned multi-items of constructs was measured using a five- point Likert scale with items ranging from strongly disagree to strongly agree. See Appendix A for details.

Data collection and sample profile

The subjects of the survey were 900 companies in Taiwan, which have actually implemented c-commerce. They were selected using the stratified sampling method from a list comprising 1,700 companies and provided by the Corporate Synergy Development Center, an official organization dedicated to promoting industrial collaboration in Taiwan. The questionnaires were mailed to the managers in charge of c-commerce in their respective companies. There were 113 returned questionnaires, which yield 103 valid responses (11.44%) for analysis after discarding invalid ones. This study adopts independent t-test to analyze non-response bias [39] by comparing the 70 earlier responses and the later 33 responses. With a significance level of 0.05, the two groups show no difference in their basic characteristics.

Therefore the non-response bias was acceptable in the study.

The sample characteristics are shown in Table 1. In years since establishment, the majority of the companies have more than 26 years of history; total 62 of them (60.19%). In partnership duration, most of the companies have more than 20 years of partnership duration; total 57 of them (55.34%). In company size, more than half of the companies have 50 or less employees; total 63 of them (61.17%). Most of them have capital under NT$ 50 million; total 45 of them (43.69%). Most companies, total 26 of them (25.24%), are in the electronic/information industry. Such a profile suggests that most of these companies are small-medium enterprises and are more dependent on the resources of their collaborative partners due to their company size. So it can be reasonably argued that these companies were quite experienced about collaborative relationship. In addition, the respondents were mostly executives; they should know very well about the c-commerce in their companies, and therefore are good representatives of survey subjects.

DATA ANALYSIS AND RESULTS

This study used partial least squares regression analysis (PLS) to analyze the data collected. PLS is frequently adopted in the study of information system in recent years; its robustness requires the smallest sample size when compared with the other structural equation modeling (SEM) methods and is appropriate for this study. This study adopted a two-stage analysis to first estimate the measurement model for scale validation and then estimate the structural model for hypotheses testing.

Table 1. Sample profile.

Company data		Frequency	%
Years since establishment	1-5	3	2.91
	6-10	7	6.80
	11-15	5	4.85
	16-20	8	7.77
	21-25	18	17.48
	Above 26	62	60.19
Partnership duration (year)	1-5	6	5.83
	6-10	11	10.68
	11-15	19	18.45
	16-20	10	9.71
	21-25	23	22.33
	Above 26	34	33.01
Number of Employee	Under 30	37	35.92
	31-50	26	25.24
	51-100	19	18.45
	101-150	3	2.91
	151 – 500	7	6.80
	Above 501	11	10.68
Capital (Million NTD)	Under 50	45	43.69
	50-100	24	23.30
	100-500	15	14.56
	500-1000	5	4.85
	1000-3000	6	5.83
	Above 3000	8	7.77
Industry	Automobile	11	10.68
	Machinery	13	12.62
	Elecrtonics	26	25.24
	Chemistry	10	9.71
	Electric engineering	9	8.74
	Consumer goods	4	3.88
	Textiles	3	2.91
	Household appliances	9	8.74
	Steel	16	15.53
	Food	2	1.94

Measurement model

First, the result of the reliability analysis is shown in Table 2. The internal consistency reliability (Cronbach's α) and composite reliability (CR) of all constructs are higher than the recommended value of 0.7, suggesting that the instrument has an acceptable reliability [12,19]. Second, in terms of the validity of the instrument, three types of validity were assessed: content validity, convergent validity and discriminant validity. The content validity was established by ensuring that the measurement items were consistent with the review of related literature, interviews with academic researchers and the practitioner experts.

Convergent validity was assessed by looking at factor loadings and the average variance extracted (AVE) from the measures, in addition to the CR values just mentioned for the reliability. As can be seen in Table 2, the factor loading values ranged from 0.775 to 0.955 which were higher than the recommended threshold of 0.5, with the t-test values of the items have all reached the significance level ($p<0.001$),; the AVE values of all constructs ranged from 0.698 to 0.895 which were also higher than the recommended threshold of 0.5 [12,19]. Moreover, the factor loading matrix suggested that the loadings of all items in all constructs were higher than their loadings in other constructs [12,19], which indicated a sound discriminant validity of the instrument.

Structural model

The proposed research model was analyzed using PLS [30]. The hypotheses were estimated by calculating the significance of the path coefficients. The result of PLS analysis, as shown in Table 3, reveals that the relationship continuance is positively influenced by resource complementarity ($p<0.001$), organization compatibility ($p<0.01$), trust ($p<0.01$), commitment ($p<0.05$) and IT capability ($p<0.001$), and supports hypotheses H1a, H2a, H3a, H4a and H5a. Relationship tightness is also positively influenced by resource complementarity ($p<0.05$), organization compatibility ($p<0.05$), trust ($p<0.01$) commitment ($pp<0.001$), and IT capability ($p<0.05$). Therefore, hypotheses H1b, H2b, H3b, H4b and H5b are also supported. Finally, collaborative performance is positively influenced by relationship continuance ($p<0.001$) and relationship tightness ($p<0.001$). So hypotheses H6 and H7 are supported as well.

The model also exhibits a good explanatory power. As can be seen in Figure 2, the five factors of partner selection explain 57.3 percent of the variances of relationship continuance and 43.3 percent of the relationship tightness, while the collaborative relationship, in terms of relationship continuance and relationship tightness, explain 76 percent of the variances of collaborative performance.

DISCUSSION

Influence of partner selection on collaborative relationship

In the fast-changing and globalization environment, an enterprise must acquire higher resource advantage to survive. Enterprises in all industries need tremendous amount of resources for the development of new products or technologies and entrance to new market; few can afford such resource along. Therefore, c-commerce is an important electronic application for corporate strategic alliance [50]. Partner selection is the first step for an enterprise to adopt c-commerce. This study finds that resource complementarity, organization compatibility, trust, commitment and IT capability can positively influence the continuance and tightness of relationships with the collaborative partners.

Table 2: The matrix of reliability and factor loading of all constructs.

Variable	Composite reliabilities	Cronbach's α	AVE	Scale Items	S.D.	t-value	RC	GC	TR	CO	IT	SUS	TIG	PP
				RC_1	0.028	31.286***	**0.881**	0.152	0.287	0.262	0.115	0.441	0.373	0.475
RC	0.882	0.783	0.698	RC_2	0.037	22.378***	**0.847**	0.148	0.265	0.274	0.119	0.413	0.293	0.380
				RC_3	0.084	9.211***	**0.774**	0.165	0.147	0.201	0.124	0.374	0.309	0.366
				GC_1	0.021	41.087***	0.138	**0.877**	0.281	0.361	0.257	0.472	0.368	0.430
GC	0.916	0.856	0.777	GC_2	0.020	42.739***	0.260	**0.895**	0.300	0.269	0.156	0.407	0.383	0.449
				GC_3	0.031	27.370***	0.084	**0.871**	0.274	0.226	0.227	0.394	0.315	0.393
				TR_1	0.029	29.954***	0.208	0.223	**0.871**	0.324	0.177	0.438	0.430	0.371
TR	0.902	0.863	0.786	TR_2	0.022	40.441***	0.238	0.315	**0.901**	0.306	0.223	0.427	0.428	0.429
				TR_3	0.021	40.988***	0.303	0.321	**0.886**	0.413	0.211	0.455	0.443	0.478
				CO_1	0.036	23.534***	0.201	0.297	0.341	**0.847**	0.092	0.361	0.435	0.411
CO	0.898	0.852	0.773	CO_2	0.027	32.851***	0.289	0.283	0.330	**0.892**	0.073	0.391	0.419	0.434
				CO_3	0.025	35.750***	0.287	0.286	0.366	**0.898**	0.185	0.438	0.379	0.467
				IT_1	0.026	34.482***	0.146	0.298	0.166	0.243	**0.881**	0.456	0.381	0.430
IT	0.885	0.809	0.724	IT_2	0.047	17.121***	0.126	0.184	0.275	0.109	**0.832**	0.376	0.234	0.319
				IT_3	0.050	16.826***	0.082	0.106	0.158	-0.063	**0.838**	0.326	0.269	0.266
				SUS_1	0.024	40.681***	0.464	0.494	0.430	0.455	0.451	**0.955**	0.599	0.737
SUS	0.935	0.904	0.830	SUS_2	0.034	26.344***	0.514	0.380	0.521	0.374	0.395	**0.887**	0.556	0.664
				SUS_3	0.039	22.553***	0.381	0.411	0.458	0.379	0.405	**0.889**	0.627	0.720
				TIG_1	0.034	27.309***	0.354	0.374	0.455	0.461	0.334	0.633	**0.930**	0.744
TIG	0.940	0.897	0.823	TIG_2	0.037	24.051***	0.339	0.381	0.461	0.436	0.300	0.561	**0.896**	0.713
				TIG_3	0.046	19.491***	0.370	0.355	0.426	0.373	0.326	0.550	**0.893**	0.730
				PP_1	0.018	49.799***	0.448	0.426	0.429	0.437	0.450	0.719	0.760	**0.935**
PP	0.962	0.941	0.895	PP_2	0.019	48.560***	0.465	0.519	0.412	0.484	0.388	0.738	0.765	**0.950**
				PP_3	0.016	57.471***	0.477	0.415	0.519	0.482	0.343	0.746	0.761	**0.952**

RC: Resource complementarity, GC: Organization compatibility, TR: Trust, CO: Commitment, IT: IT capability, SUS: Relationship continuance, TIG: Relationship tightness, PP: Collaborative performance。 (***：p<0.001；**：p<0.01；*：p<0.05)

Table 3: Results of hypothesis testing.

Independent variable	Dependent variable	Path Coefficient	Standard Error	t value	Results of hypothesis testing
Resource complementarity	Relationship continuance	0.299	0.076	3.948***	Support H1a
Organization compatibility		0.237	0.081	2.917**	Support H1b
Trust		0.203	0.076	2.669**	Support H1c
Commitment		0.167	0.068	2.447*	Support H1d
IT capability		0.293	0.069	4.278***	Support H1e
Resource complementarity	Relationship tightness	0.206	0.087	2.243*	Support H2a
Organization compatibility		0.181	0.083	1.980*	Support H2b
Trust		0.246	0.078	3.134**	Support H2c
Commitment		0.228	0.068	3.411***	Support H2d
IT capability		0.198	0.084	2.398*	Support H2e
Relationship continuance	Collaborative performance	0.440	0.068	6.469***	Support H3
Relationship tightness		0.519	0.075	6.926***	Support H4

(***：p<0.001；**：p<0.01；*：p<0.05)

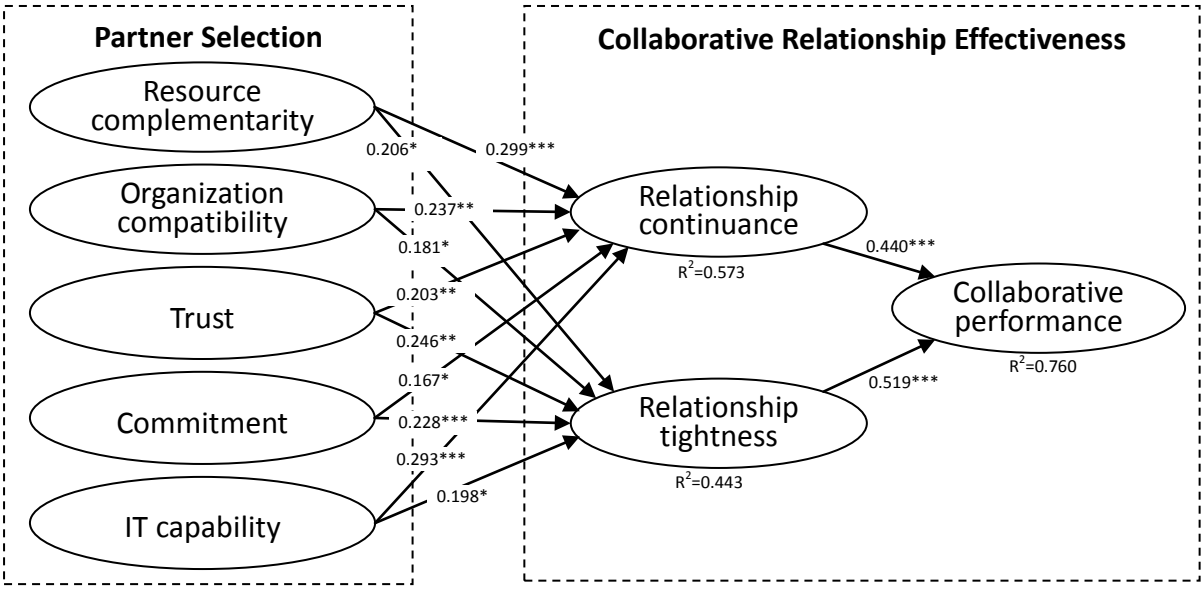

Figure 2: Results of the structure model analysis.

Complementary resource and capability of partners can influence the willingness to collaborate on both sides, promote close interaction, information exchange, knowledge

sharing, process integration, and therefore better collaborative relationship. When selecting a collaborative partner, the organization compatibility between both sides must be considered; the more similarities they share, the more tolerant they are to each other during collaboration, which is helpful to the continuance of the partnership. A higher cultural compatibility between the partners makes inter-organizational communication easier; it allows more open learning and exchange and promotes frequent relational connection [28]. Therefore, choosing a partner with organization compatibility can help with developing a longer and tighter collaborative relationship.

Trust is also an important factor for partner selection. An effective collaborative relationship is based on mutual trust. A higher trust developed during the early stage of collaboration may attribute to the development of a closer interaction and the willingness to dedicate assets. Therefore it can help with the development of a tighter relationship. Trust is also a critical factor for an enterprise to share information with its partners. A higher trust can reduce unnecessary costs of transaction and supervision, encourage more attention from both sides to the collaboration and sustain such a relationship. Therefore, trust is the key factor to the success of a long-term relationship that allows the partners to solve potential risks with more tolerance when dealing with conflict or temporary power imbalance [32].

Commitments from both sides to the collaborative project should be considered when selecting a partner. Commitment refers the recognitions and guarantees from both sides for their relationship, including the provision of resource and mutual support for the collaborative project. It is the willingness driven by emotion to maintain the binding of their relationship and can be regarded as an approval for the future collaboration. Mentzer et al. [44] argued that commitment is the core factor to the success of a long-term strategic partnership and represents the willingness of bearing risks and sacrificing short-term interest that indicates the intention for a deeper relationship in exchange for long-term interest.

Finally, IT capability is also an important factor for selecting a partner for collaborative commerce. IT is an effective tool often used to strengthen the binding between companies and promote interaction between the partners. Therefore IT capability has a positive influence on the development of collaborative relationship. Applying IT in the establishment of an inter-organizational collaborative system not only may form a close binding between the partners, but also obtain electronic competitive advantages [45].

Influence of collaborative relationship on collaborative performance

The study results show that collaborative relationship has positive influences on collaborative performance. As the environment changes and IT development progresses rapidly, enterprises have learned the importance of collective survival and collective prosperity through partnership. A good partnership is not only helpful to develop innovative products, shorten the new products' time to market, reduce operational costs, improve

productivity, but also may create competitive advantages to benefit the partner enterprises. Tight interaction between the collaborative partners encourages both sides to invest resource, share information promptly and adapt to the change of the external environment; therefore it may lead to better results [5]. The continuance of the collaborative relationship promotes mutual understanding, increases confidence in investing assets required for the collaboration, encourages expectations on long-term partnership, binds the interests of the partners, and therefore increases collaborative performance [22].

CONCLUSION

This study investigates the role of the collaborative relationship in the influences of the factors adopted in c-commerce partner selection on the collaborative performance. After reviewing the related literature, resource complementarity, organization compatibility, trust, commitment and IT capability were considered the major factors of partner selection in the study, and the collaborative relationship was divided into relationship continuance and relationship tightness. The results analyzed on the data collected from a questionnaire survey show that the five factors of partner selection have great influence on the two dimensions of collaborative relationship, and the collaborative relationship combining the relationship continuance and tightness has major impact on the collaborative performance.

Collaborative relationship plays a mediating role in partner selection and collaborative performance. This study contributes to showing the critical role of collaborative relationship in c-commerce. Despite the importance of selecting a partner for the c-commerce, it can only be applied to increase collaborative performance though a good collaborative relationship. This study divides the collaborative relationship into two constructs. The study findings show that although the five factors of partner selection have a higher explanatory power on relationship continuance (R^2=0.573) than on relationship tightness (R^2=0.443), the effect of relationship tightness on collaborative performance (path coefficient 0.519) is greater than that of relationship continuance (path coefficient 0.44). That suggests enterprise partners may improve the collaborative performance with process integration or system connection that encourages tight interaction.

This study provides several managerial implications. First, an enterprise must take into consideration on a wider scope when selecting a partner for c-commerce. In the globalized business environment, selecting a collaborative partner is a crucial strategic issue. According to the findings of this study, resource complementarity, organization compatibility, trust, commitment and IT capability will influence the collaborative relationship and in turn the collaborative performance. Therefore when an enterprise selects its collaborative partner, it must consider comprehensively instead of one particular factor. Next, when adopting c-commerce, attention should be paid on relationship continuance and relationship tightness to achieve collaborative performance. For this purpose, an enterprise should confirm the issues of resource complementarity and organization compatibility with its

partners, work hard to reduce the possibility and degree of conflict, and collaborate on establishing the initial trust and commitment in order to develop a continuing and tight relationship.

There exist several limitations in this study. First, though various standards for evaluating collaborative performance are possible from different perspectives, this study adopts the degrees of satisfaction and goal attainment of a collaboration project as the measures for collaborative performance that are subjectively determined. Second, the questionnaire survey is designed from the aspect that an enterprise selects its collaborative partner, and the information of their partners is not collected. Finally, the development of a relationship needs an extensive period of time. This study adopts a cross-sectional research and is unable to develop a more comprehensive understanding about the development process of a collaborative relationship. These issues also offer opportunities of further study.

APPENDIX A

The structure of the survey instrument

The instrument is measured using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree).

Part 1: Consideration factors in selecting a collaborative partner

1. The resource owned by a collaborative partner is valuable to each other.
2. Both collaborative partners need the resource of each other to achieve their respective goals.
3. The resource provided by a collaborative partner is the resource the other partner lacks of.
4. The collaborative partner’s business management philosophy is compatible
5. The goal of the collaborative partner is compatible.
6. The code of conduct adopted by the collaborative partner is similar.
7. The collaborative partners have great faith in each other.
8. The collaborative partner is willing to comply with the commitment agreed by both sides.
9. The collaborative partner will consider the impact that its partner will have to sustain when making a critical decision.
10. The partner values the collaboration very much.
11. The partner is willing to provide human resources for this collaboration.
12. The partner will not easily terminate the collaboration.
13. The collaborative partner has high capacity in computer and information.
14. The collaborative partner is capable to establish and maintain the computer network connected to each other.
15. The collaborative partner has committed considerable investment on new information

technology software and hardware.

Part 2: Effectiveness of the collaborative relationship

1. If there is any other opportunity, your company is still willing to continue working with the current partner.
2. The collaborative partners have very high loyalty to each other.
3. The collaborative partners are willing to devote their best efforts for each other.
4. The collaborative partners are tightly connected in business process.
5. The negotiations on critical issues concerning the collaboration between the collaborative partners are conducted by personnel of higher ranks from both sides.
6. The partners are willing to invest on the proprietary equipment required for the collaboration.
7. The collaboration between the partners has attained the original goals.
8. Your company is satisfied with the result brought by the collaborative partnership.
9. Your company believes the collaborative partnership is worthwhile.

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D3 – Organizational-management perspectives

D3.1 **Geometrical modeling of industrial workshop allocation**
Zbigniew Pastuszak

D3.2 **Identifying barriers and enablers for the implementation of risk management in a project network**
Leena Pekkinen

D3.3 **Materiality analysis for CSR reporting in Spanish SMES**
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D3.4 **The process to determine possibilities and needs for mobile maintenance with mobile technology**
Jere Backman

GEOMETRICAL MODELING OF INDUSTRIAL WORKSHOP ALLOCATION

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ABSTRACT

The paper concerns the problem of industrial workshops allocation regarding the logistics and economics point of view. The function goal is – the minimal transportation costs. Usually in the workshops allocation projecting we are doing different kind of calculations. Traditionally those calculations are iterative and follow step-by-step procedure. In this paper we are going to use a new method, based on the Theory of Connection (ToC) and we try to answer to the question: how to use the geometrical modeling to support the workshops deployment. Applying the new method to solve an industrial problem we are developing a new tool supporting the industrial engineers in production processes organization and management.

Keywords: Production, modeling, workshop, allocation, theory of connection

INTRODUCTION

In this paper, we are using the theory of connection (ToC) based approach for formulation of mathematical models of engineering and management processes, especially concerning the workshops placement processes. Theory of connection (ToC), previously known as manufacturing system theory, in the form it is presented here, is due to the work of the Scandinavian School of Systems Theory for the past 30 years (Bjorke, 1995). Additionally the tool general purpose Petri net simulator (GPenSIM, 2009) can be used for processes simulation.

The idea behind ToC is to bring geometry and algebra together; we use geometric modeling to model an physical phenomenon, make a set of algebraic equations out of this geometric model. In the next step, by using a computer these equations can be solved. The usefulness of ToC is that, different subsystems of different disciplines can be modeled and integrated by performing the same procedure; this is very important for fields like e-commerce as e-commerce involves diverse disciplines like manufacturing, business management, supplier selection, computer hardware and software, control systems etc (Davidrajuh, 2007; Davidrajuh and Melberg, 2008, Davidrajuh and Pastuszak, 2010). The modeling approach based on ToC is explained below.

As shown in figure 1, a system consists of three fundamental components, such as *elements*, *connections*, and *sources*.

The elements carry all the physical or economical *properties* of the system. Elements are the building blocks of the physical system, and can be based on *nominal scale* or *ordinal scale* form (Haavardtun, 1995). Nominal scale element means, the direction of flow through it depends on the type of the production. This means, nominal scale elements are bi-directional. For ordinal scale elements, like a production step, the direction of flow through it is given by the element itself, and does not change with applied source or potential across it.

When there is no connection between the elements, the set of isolated elements is called the *primitive system*. The connections reflect how the elements influence each other and it represents the structure of the system. The set of connected elements is called the *connected system*. Finally, the sources reflect the influence between the total system and the environment. Sources are the environment's influence on the system; in an electrical circuit, source s could be current or voltage sources; in production planning, demand of products, startup-setup times, costs involved are some of the sources.

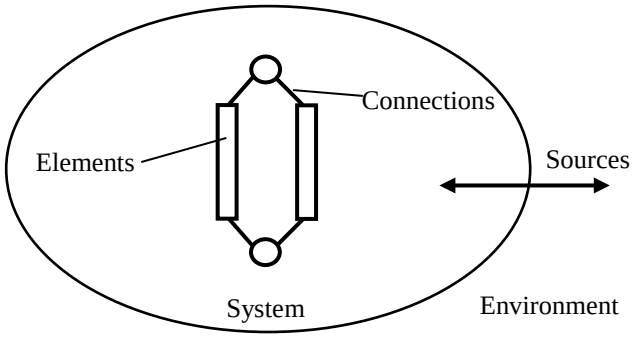


Figure 1: The System model

THE APPROACH

The research problem discussed in this paper is the existence of redundancy in workshop placement. The industrial processes join with a number of collaborating workshops (machines, people, etc.), to manufacture a class of product with the characteristics such as qualitative, agility, and leanness, to achieve minimal transportation cost. When market requirements are changed, a new class of products or an improved version of the product should be turned out to meet the new market requirements. In this case, we can observe the change of a number and a type of operations and as well as the workshops sequence in the manufacturing processes. The enterprise may seek for a new combination of collaborating workshops that are more suitable to manufacture the new class of products; thus the main aspect of our idea is dynamic logic of organization and reorganization of workshops placement and collaboration.

Let we use the following example. We are producing some 4 products (details). The production plant is consist of 6 machines describes at the Table 1. The production operations and quantity are described at the Table 2.

Table 1: Workshops information.

No.	Name of the machine	Symbol
1	Saw (cutting machine)	PM 120
2	Lathe (machine tool)	TUM 35 x 800
3	Drill	WKA 40
4	Milling machine	FYC 26
5	Grinder	SWA 25
6	Control position	KT

Table 2: Details and technology process information.

No.	The order of the operations on the machines	Production plan	Weight of the detail [kg]
1	1 – 2 – 3 – 4 – 5 – 6	100	1.5
2	2 – 3 – 6 – 5 – 4 – 1	150	2.0
3	1 – 3 – 5 – 4 – 6 – 2	200	1.2
4	1 – 2 – 3 – 6 – 4 – 5	180	1.0

Let we take the assumption that all of the details are produced within the same number of the operations. The production process criterion is to minimize of the transportation operations.

Following the CRAFT (*Computerized Relative Allocation of Facilities Technique*) method, we can establish the formula below:

$$Q = \sum_{i=1}^{n} \sum_{j=1}^{n} S_{ij} \cdot L_{m(ij)} \rightarrow \min$$

where:

Q – goal function (sum of load of the workshops that have to be allocated),
n – number of the workshops to allocation,
i, j – allocated workshops numbers,
$m_{(i)}$ – place of allocation of the i object (workshop),
$m_{(j)}$ – place of allocation of j object (workshop),
S_{ij} – ij-element of the matrix of workshops load,
$L_{m(ij)}$ – a distance between two of m-workshops, contains of i and j objects.

After Q function calculation we can get the begin allocation of the workshops by creation of the first workshops allocation vector which is the permutation:

$$P = \{p(1), p(2), p(3), \ldots, p(n)\},$$

is makes possible following changes:

$p(1) \leftrightarrow p(2),\ p(1) \leftrightarrow p(3), \ldots,\ p(1) \leftrightarrow p(n),$
$p(2) \leftrightarrow p(3),\ p(2) \leftrightarrow p(4), \ldots,\ p(2) \leftrightarrow p(n),$
$\ldots,$
$p(n-1) \leftrightarrow p(n).$

We change the position of the workshops deployed at the places: 1, 2; 1, 3; ..., 1, *n*; 2, 3; ..., 2, *n*; ... , *n* – 1, *n*. The environment of the solution is consist of $1 \cdot \frac{2 \cdot n}{n-1}$ points.

The goal function is going to be as follows:

$$Q^0 = \frac{1}{2} \cdot \sum_{i=1}^{n} \sum_{j=1}^{n} S_{p(i)p(j)} \cdot L_{ij},$$

where:

$S_{p(i,j)}$ – matrix of the connections of *p*-objects allocated at *i* and *j* workshops,
L_{ij} – a distance between *i* and *j* workshops.

After the change of objects allocated at the place *x* and y, we will observe the change of the goal function (*Q*) value:

$$Q_{p(x)p(y)} = \frac{1}{2} \cdot \sum_{i=1}^{n} \sum_{j=1}^{n} S_{p(i)p(j)} \cdot L_{ij} + \sum_{\substack{i=1 \\ i \neq x,y}}^{n} \left(S_{p(x)p(i)} \cdot L_{yi} + S_{p(y)p(i)} \cdot L_{xi} \right) + + S_{p(x)p(y)} \cdot L_{xy}.$$

Finally, the new value of goal function will be equal to:

$$\Delta Q_{p(x)p(y)} = Q^0 - Q_{p(x)p(y)}.$$

And, after change:

$$\Delta Q_{p(x)p(y)} = \sum_{\substack{i=1 \\ i \neq x,y}}^{n} \left[S_{p(i)p(x)} - S_{p(i)p(y)} \right] \cdot \left(L_{ix} - L_{iy} \right).$$

We have to change the workshops positions till the change of goal function value is decreasing.

So, backing to our example we can do the following calculations (see Table 3).

Table 3: The flow of products between workshops [kg].

	1	2	3	4	5	6
1	–	150 180	240			
2		–	150 300 180			
3			–	150	240	300 180
4	300			–	150 180	240
5				300 240	–	150
6		240		180	300	–

The direction of the flow is no important – so our calculations can be as showed at the Table 4.

Table 4: Symmetrical matrix of the workshops connections.

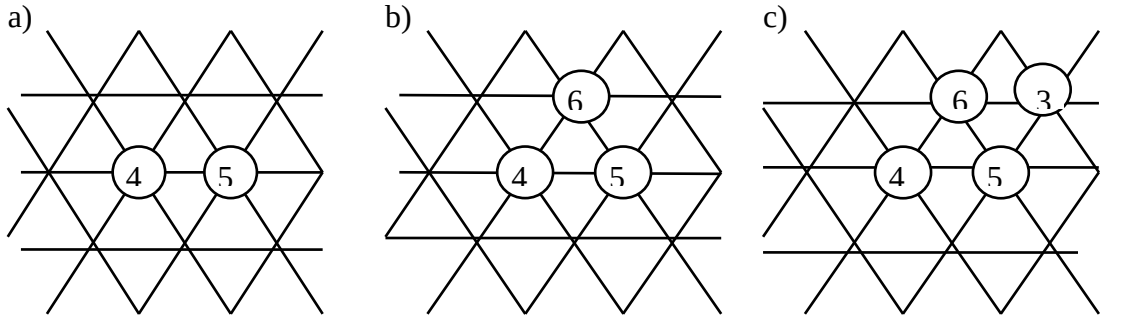
	1	2	3	4	5	6
1	–					
2	330	–				
3	240	630	–			
4	300	0	150	–		
5	0	0	240	870	–	
6	0	240	480	420	450	–

The highest value is the limitation for our production plant and it influences on the goal function value, so limited workshops have to be allocated both as first (Table 5).

Table 5: The order of workshops allocation.

Iteration	Order of workshops	1	2	3	4	5	6
	4	300	0	150	–	–	420
	5	0	0	240	–	–	450
1	Σ	300	0	390	–	–	870
	6	0	240	480	–	–	–
2	Σ	300	240	870	–	–	–
	3	240	630	–	–	–	–
3	Σ	540	870	–	–	–	–
	2	330	–	–	–	–	–
4	Σ	870	–	–	–	–	–
	1	–	–	–	–	–	–

After the calculation shown at the Table 5 we have to calculate next the goal function value (stating from No. 4 and No. 5 workshop) – it was shown at the Figure 2. The final value of Q function for our case is 5070 kg (Figure 2.e).



$Q_{4\text{-}5}$=870x1=870 Q_6=870+420x1+450x1=1740 Q_3=1740+150x2+240x1+480x1=2760

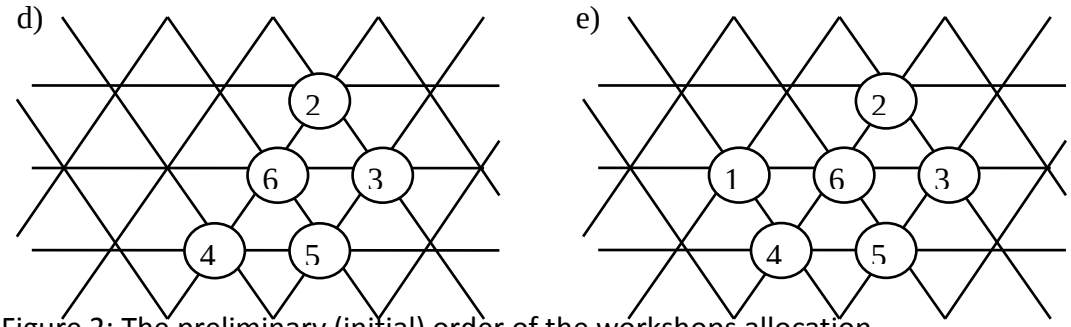
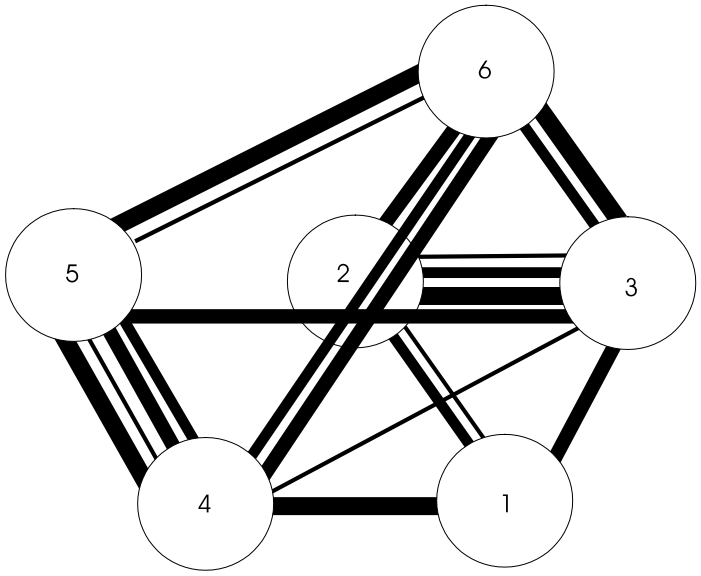


Figure 2: The preliminary (initial) order of the workshops allocation.

Q_2=2760+0x2+0x2+240x1+630x1=3630 Q_1=3630+300x1+0x2+0x1+240x2+330x2=5070

The flow of the details was shown at the Figure 3.



- 150 kg
- 180 kg
- 240 kg
- 300 kg

Figure 3: Flow of the details between workshops allocated [kg].

The model of the production hall – see Figure 4.

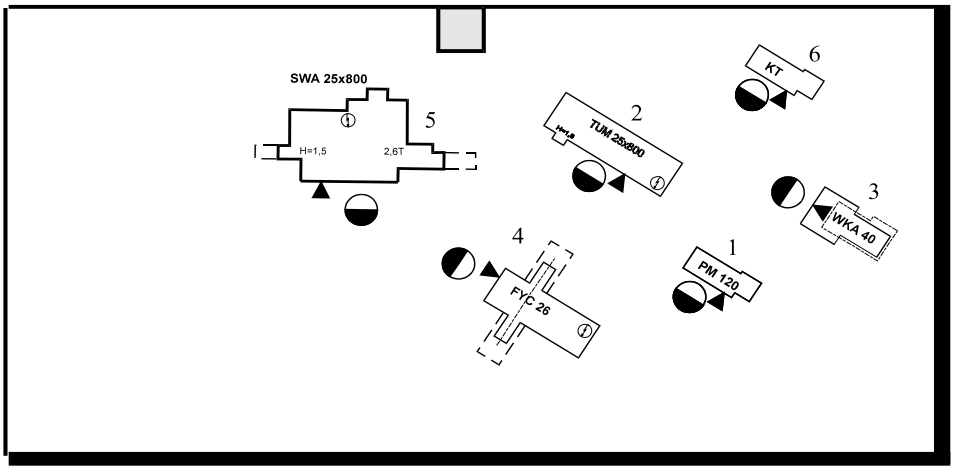


Figure 4: Production hall model (scale: 1:100).

CONCLUSION

This paper shows a new approach for detection and elimination of redundancy in workshops placement. The approach uses workflows. The working example proves that the approach can be put to use by using a Petri net based modeling and analysis tool. This paper also presents a Theory of Connection (ToC) based approach for modeling physical systems. The main benefit using ToC based approach is that the approach emphasizes the connection between the primitive elements that compose the system; in another words, geometry is used for system modeling.

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IDENTIFYING BARRIERS AND ENABLERS FOR THE IMPLEMENTATION OF RISK MANAGEMENT IN A PROJECT NETWORK

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ABSTRACT

Increasingly, projects are executed by networks of organizations. The networked form of organizing has many important implications for project risk management. Instead of focusing on risk management of single actors in order for risk management to be successful risk management activities should be integrated on a project network level. This study aims to examine the barriers and enablers for the implementation of risk management in a project network through an empirical analysis of the sales phase of one internally networked project of a globally operating project-based company. With regard to network level risk management, the paper identifies and describes the following five barriers: strict divisional approach, illusion of common approach, lack of formal structure of the common approach, lacking specification of the responsibilities and targets. In addition, three identified co-ordination mechanisms that support risk management on a project network level are described.

Keywords: risk management, project network, project sales phase, mechanisms of co-ordination

INTRODUCTION

Background

Project risk management has nowadays and acknowledged role as one of the key processes and research fields of project management (e.g. Chapman and Ward, 2003; Miller and Lessard, 2000). Recent project management studies have also emphasized the networked, inter-organizational nature of projects and argued that more attention should be paid to the study of projects as inter-organizational networks (Ahola; 2009; Cova et al. 2002; Engwall, 2003; Söderlund, 2004). Despite the central role of risk management and project networks in prior and current project management research only limited attention has been addressed to risk management in a networked project setting. The networked form of organizing has many fundamental implications for project risk management: The heterogeneous actors in project networks have contradictory and conflicting objectives which pose fundamental coordination and integration challenges (Flyvbjerg et al., 2003; Hellgren and Stjernberg, 1995; Morris and Hough, 1987). Therefore, a broader perspective concerned with managing the risks in networked projects and improving risk management -

related co-operation and integration over organizational boundaries within the project networks is needed. Instead of focusing on risk management of single actors in order for risk management to be successful risk management activities should be integrated on a project network level (Pekkinen, 2010).

The purpose of the present study is to examine the barriers and enablers for the implementation of risk management in a project network. The first research question of the paper is: What are the main barriers for implementing project risk management in a project network? In addition, we are interested in exploring the mechanisms that support the execution of risk management in project networks. Hence, the second research question of this paper is formulated as follows: What kinds of co-ordination mechanisms support the implementation of project risk management in a project network? In this paper the co-ordination mechanisms refer to activities that support the management of the interface processes related to risk management between the different organizations of the project network. To answer our research questions we examined risk management practices in the sales phase of a networked project in a globally operating project-based firm. In this paper our attention is on internal project network of the case company's delivery project. This internal network consists of sovereign business divisions. The analysis of the barriers and enablers for the implementation of risk management in a networked setting draws from literature on project risk management, project networks and coordination mechanisms in project-based firms.

The paper is structured as follows. Introduction describes the background and motivation for the study. In the literature review section research on project risk management, risk management in project networks and coordination mechanisms in project-based firms is reviewed. The next section introduces the research method and context. The empirical findings present the identified barriers for the implementation of risk management on a project network level. Furthermore, the coordination mechanisms that support the project network level risk management are presented. Finally, we discuss the findings in the light of the existing project risk management literature and summarize the contributions of the study.

LITERATURE REVIEW

Project risk management

Project risk management has nowadays an acknowledged role as one of the key processes of project management. Furthermore, project risk management is a widely researched area in project management research (e.g. Chapman and Ward, 2003; Floricel and Miller, 2001: Kähkönen and Artto, 1997; Miller and Lessard, 2000). Prior research on project risk management has primarily focused on the concept of project risk and on the identification of risk sources and effective managerial approaches and tools for reducing risks in projects (Chapman and Ward, 2003; Ward and Chapman, 2003).

There is a constant debate concerning the definition of risk in the context of project management and the term's relation to the concept of uncertainty in particular (Ward and Chapman, 2003, 2004; Miller and Lessard, 2001; Perminova et al., 2008). In the project management literature the term 'risk' is most often defined as the possibility that events, their resulting impacts and dynamic interactions, may turn out differently than anticipated (Ward and Chapman, 2003, 2004; Miller and Lessard, 2001). Similarly, according to Project Management Body of Knowledge that is an acknowledged project management standard, risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective (PMI, 2008). In this definition both the threats and the opportunities are present. Traditionally, the emphasis of the risk assessment has been with threats rather than opportunities (Ward and Chapman, 2003). Various earlier studies have presented informed classifications on the sources of risks (Kähkönen and Artto, 2008; Ward and Chapman, 2003; Floricel and Miller, 2001). Whilst most of the studies have focused on the categorization of project risk sources in a single actor project context only few studies have addressed risk sources in networked multi-actor project (Artto et al., 2008; Hallikas et al., 2002; Kähkönen and Artto, 2008; Pekkinen, 2010; Ward, 1999).

The linear, rational and planning-oriented view towards projects and their management is also reflected in the existing project risk management applications and structured process guidelines: in an ideal process risks, their probabilities and impacts should be explicitly identified and estimated and decisions for appropriate responses and monitoring and control principles documented. Actually the whole planning oriented project management approach can be considered as a fundamental approach for reducing uncertainty in projects: through detailed planning and use of specific project management methods and tools, risks and uncertainties in projects are considered to be minimized and better managed (Morris and Hough, 1987). Accordingly, the well known formal risk management processes and standards (PMI, 2008; APM, 2006; Chapman and Ward, 2003) typically consist of a generic process description including three core project risk management processes: risk identification, risk evaluation and risk response planning (Kähkönen and Artto, 2008). Furthermore, within the current view of project management as a lifecycle process, project risk management is seen as an encompassing process, starting at project definition, continuing through planning, execution and control phases, up to completion and closure (Raz et al., 2002). All changes done in the project execution plan and changes of the ambient circumstances are sources of new risks and, therefore, continuous monitoring of the environment is needed.

Risk management in project networks

Increasingly, projects are executed by networks of organizations (Ahola, 2009; Artto et al., 2008; Söderlund, 2004; Hellgren and Stjernberg, 1995). Even though interrelationships are a new area of interest there has been very little discussion on the functioning and dynamics of project networks outside the field of project marketing (Cova and Salle, 2005). Hellgren and Stjernberg (1995) advocate that studies of collaborative arrangements and networks usually concern long-term inter-organizational arrangements, such as acquisitions and joint ventures. Project networks consist of relationships between actors or organizations to establish robust

capabilities to perform the tasks of the project to achieve the set targets of the project (Hellgren and Stjernberg, 1995). Consequently, project networks are intentionally developed networks – they are formed in order to create capital assets for the buyer over a certain period of time (Skaates and Tikkanen, 2003). Project networks can therefore be seen as an instrument of achieving specific, pre-defined targets. At a casual glance it may appear that this common target acts as the temporary underlying force which glues the project network actors together, and is the raison d´être of the project network (Hellgren and Stjernberg, 1995). Nevertheless, the individual actors involved in the temporary project network might have other rationales and motivations for their participation other than completing specific short-term tasks. Consequently, the heterogeneous actors in project networks have oftentimes contradictory and conflicting objectives which pose fundamental coordination and integration challenges in the project network (Morris and Hough, 1987; Flyvbjerg et al., 2003). In such networked projects, the role of effective risk management is emphasized as one of the critical success factor of the project.

The networked form of organizing has many important implications for project risk management. In particular, the literature on large projects lists various major challenges and suggestions in organizing and managing a project enterprise as a network of several participating organizations, especially related to analyzing risk, uncertainty and success issues (Flyvbjerg et al., 2003; Kharbanda and Stallworthy, 1983; Klemetti, 2006). Firstly, the network structure in itself poses new types of risks. The multiplicity of the project actors, as well as the interactions and relations between the actors are a source of uncertainty in the project network. Risk in the network context can be defined as an uncertain event or condition that results from the network form of work, having an impact that contradicts the expectations. An event is at least partially related to other actors in a network (Kähkönen and Artto, 2008). In other words, risks in project networks are due to relationships and interactions between project network parties (Artto et al., 2008). Prior literature has addressed to a limited extent the sources of risks in networked project settings (Artto et al., 2008; Kähkönen and Artto, 2008; Hallikas et al., 2002; Klemetti, 2006; Söderholm, 2008; Ward, 1999). Furthermore, the majority of the existing studies have focused on the nature of relationships of project network actors as a risk source. However, Ward (1999) states that the involvement of multiple actors in the project execution introduces uncertainty arising from the ambiguity related to the following six aspects: Specification of responsibilities, perceptions of roles and responsibilities, communication across interfaces, the capability of parties and contractual conditions and their effects.

Furthermore, the networked project setting highlights the importance of a broader perspective on risk management. Complex delivery projects are typically networked efforts where the traditional single company oriented risk management approach can be considered to result merely in too limited solutions (Artto et al., 2008). Instead of focusing on risk management of single actors in order for risk management to be successful, risk management activities should be integrated on a project network level (Artto et al., 2008; Pekkinen, 2010). Therefore, a broader perspective concerned with managing the risks in networked projects and also improving risk-related co-operation within the project networks is needed. Especially co-

operation and integration over organizational boundaries is required in project networks in order to ensure efficient and effective risk management approach. According to Kähkönen and Artto (2008) taking into account the dynamism of the project, interactions, interrelations as well as continuous risk register updating and scanning of an environment should be emphasized in the risk management approach in project networks. However, the current risk management literature does not fully appreciate the complexity and dynamism of the whole network of project actors.

Coordination mechanisms in a project-based firm

Recently, considerable interest has been addressed towards project-based firms as distinctive kinds of economic actors due to the increasing significance of project-based forms in organizing economic activities in many industries (Hobday, 2000; Wikström et al. 2009; Whitley, 2006). The term project-based firm refers to a company that organizes most of its internal and external activities around projects (Hobday 2000; Wikström et al. 2009). Both firms that use projects as their primary productive activity and firms that organize only a part of their activities around projects can be referred to as project-based firms (Artto et al. 2011).

Intra-organizational and inter-organizational integration in project-based firms aims to break the boundaries between functions and between companies. The project-based organization poses diverse challenges to its managers, one of which is to integrate the differentiated parts of the organization to work towards the goal of the whole organization. Intra-company integration in a globally operating project-based firm, in particular, aims to overcome the functional silos and divisional boundaries of the different sovereign divisions. It is typical that due to differentiation each department and division develops its own functional specialization, time horizon, operating practices, goals and jargon (Daft and Lengel, 1986). In the context of risk management the phenomenon of disintegration of risk management related to the separation of risk management activities e.g. between different business units and functions has been recently addressed by Ruuska et al. (2010).

Integration techniques or coordination mechanisms are decisions on how to manage and coordinate the interface processes. Through the adoption of integration techniques, firms may improve efficiency and effectiveness of intra- and inter-organizational interface processes. In the existing literature different types of classifications on inter-organizational coordination mechanisms exist (Daft and Lengel, 1986; Galbraith, 1974). Naturally, the versatile integration techniques and coordination mechanisms can be classified in diverse ways. In general, any administrative tool for achieving integration among different units within an organization can be counted as an integration mechanism (Martinez and Jarillo, 1989). Typically coordination mechanisms are divided into impersonal mechanisms based on authority (e.g. routines, rules and procedures, formalization, planning and programming, IT systems) and subtle integration mechanisms that are based on formal and informal communication (e.g. group problem solving, integration roles, sosialization) (Salli, 2011) . Existing project management research presents various examples of both subtle and

impersonal mechanisms applied in project-based firms (DeFillippi, 2002; Hobday, 2000; Prencipe and Tell, 2001).

In this study coordination mechanisms are divided into different categories (drawn from Galbraith, 1974; Daft and Lengel, 1986). An important coordination mechanism is information and process integration techniques: through accurate information sharing (e.g. e-mails, voicemails, decision support systems) functions have better possibilities to coordinate the functioning of the whole system. In turn, integration through standardized and formalized actions (Galbraith, 1974) involves use of written policies, rules and standard procedures. Communication and sharing of information are fundamental in facilitating and ensuring smooth co-operation between organizational units. Galbraith (1974) also presents the coordination by targets or goals as a means to lead the different parts of the organization towards the same ultimate target. Here, the critical issue is how to set right type of subgoals. Further, integrator roles such as cross-organizational teams, group meetings and interface roles are an important source of co-ordination as well as integrated management techniques such as contracts, agreement practices and joint mechanisms for problem solving (Daft and Lengel, 1986). These mechanisms are designed to facilitate communication between interdependent units or groups in an organization (Galbraith, 1974).

METHODOLOGY

To study the barriers and enablers for implementing project risk management in a project network a qualitative single case study was conducted (Yin, 2002). The scarcity of the risk management research in a project network context made us to select the case study research strategy. Qualitative research strategy was selected to empirically study the preconditions of efficient and effective risk management in the project network context of a globally operating project-based company. In this study the key persons working in the sales phase of the project network of the case company were interviewed.

The case company delivers world wide new production lines, departments of the production lines and modernizations of the departments for the pulp and paper industry as an EPC contractor. Approximately 100 projects are in active phase simultaneously. Formerly risk management in the case company was conducted on an individual project level. This was the case also in such projects where different divisions of the case company delivered their own projects to the same end customer, hence forming an internal project network. In this case study the practices and processes of risk management during the sales preparation phase were studied from the viewpoint of the internal project network. The studied case project is formed from different divisional projects forming therefore a large project network with large scope of supply. Thereby it is a representative project to study risk management in the project network. In this study the risk management activities of the case project’s network are studied particularly during the project sales phase.

The destination country of the case project is in South-America. The proposed production line consists of six separate departments. The delivery of these six departments will be executed by six parallel projects forming the studied internal project network. These six projects have some common areas in the field of civil construction and automation, instrumentation and electrification which will be executed as matrix projects. In the case study, new production line consisting of product concept of proven technology, monetary value of the turnkey project is > 300 USD and it will be built in challenging site conditions. The degree of coordination during the proposal preparation varies from weak coordination to a common approach in different disciplines in the project network. This is illustrated in the Figure 1.

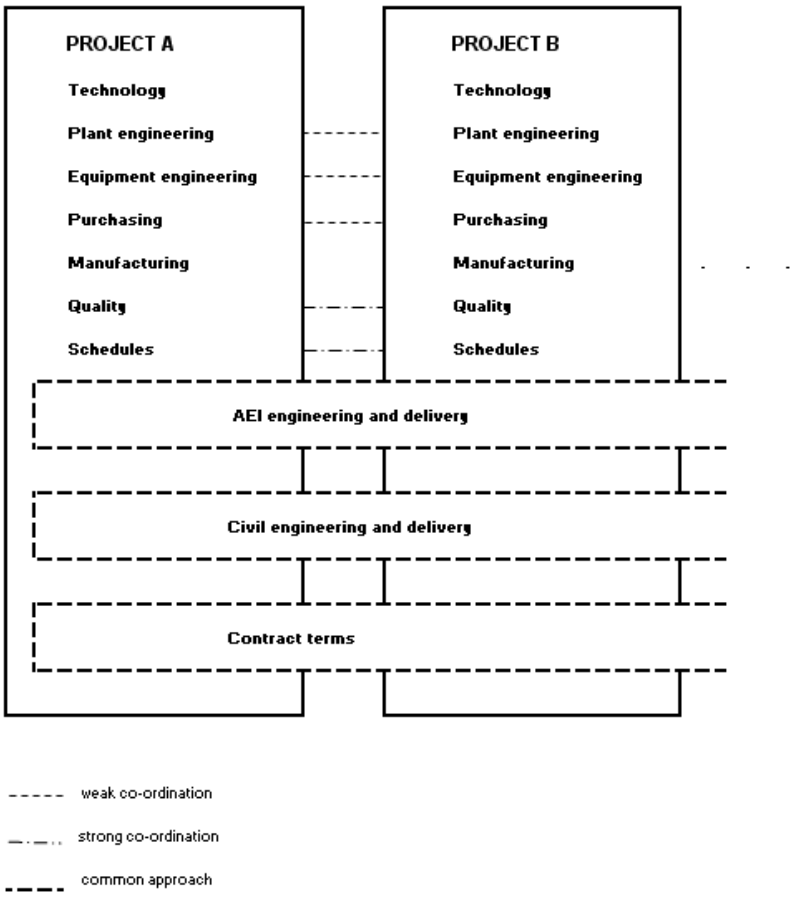

Figure 1. Different degrees of coordination in the sales phase

Persons working in the sales phase of the project to be executed with an internal project network structure were interviewed. The interviews were semi-structured lasting 45 - 90 minutes. The topics of the interviews were 1) comparison of the proposal to the other proposals of the own division with regard to technology, scope of supply, time schedule and complexity of the project, 2) proposal phase practises specified for this proposal, 3) risk

management practices and tools of the division as well as 4) risk management practices of the proposal of the project to be executed with an internal project network structure. Totally six interviews were conducted of which four with a wide perspective over the whole project network were transcribed. These four interviewed persons included one sales person, two persons with coordination responsibilities and one technology expert.

The interview data was content analyzed by two researchers. Analysis codes were generated based on the various reading rounds of the interview transcripts and literature on project risk management. Several barriers for risk management on a project network level were recognized. Furthermore, practices enabling and supporting risk management in the project network were identified. The following five different categories of barriers were observed: strict divisional approach, illusion of a common approach, no formal structure of the common approach, specification of the responsibilities and lack of common targets. Also many indicators of coordinating practices that supported risk management on a projects network level and were present in the sales work were found from the data. These practices were categorized into three categories as follows: common, competent and experienced resources in the sales work, group meetings and information sharing.

EMPIRICAL FINDINGS

In the interviews the risk management practices in the sales phase of the project to be executed with an internal project network structure were studied. Risk management practices of the individual project as well as practices of the project network were studied.
Based on the content analysis several barriers for implementing risk management in the project network level were identified. Mainly these barriers have their roots in the high degree of autonomy of the individual projects and in the own procedures and processes of the proposal preparation of separate divisions inside the globally operating project-based company. These barriers are related to the approach to the sales process, formulation of the work in the structured way with determination of the responsibilities and target setting of the proposal work. Based on the data analysis, it also appeared that there were several coordination mechanisms supporting the risk management of the internal project network in the sales phase. The nomination of competent and experienced persons in the role of integrator, group meetings and information sharing practices were notified as mechanisms enabling more efficient and effective risk management on a project network level.

Barriers

Barriers of the risk management in the project network prevent network level risk management in the sales phase. This fact results in only partly optimized common proposal with only partly harmonized common project execution plan.

Based on the data analysis, the following five barriers of the risk management in the project sales phase in the case project network were identified.

1. Strict divisional approach
2. Illusion of common approach
3. No formal structure of the common approach
4. No specification of the responsibilities
5. Lack of common targets

Strict divisional approach

The first category of divisional approach to risk management deals with the degree on which risk management is performed in the project network. In the case company most of the projects are executed as single, individual projects to the end customer without any relations to the other divisional projects of the company. Only in very few projects there are two or three divisions involved. The proposal of the whole production line is an infrequent case. Divisions prepare their proposals with regard to technology, the scope of supply and estimations quite independently resulting in very strong divisional approach during the sales phase of the case project network. We found evidence that the proposal work generally and risk management particularly are done independently by divisions as can be perceived from the following three quotations from the interviews of the schedule coordinator and technology expert.

> *" Divisions purely work for themselves."*
>
> *"In my opinion risks inside divisions are rather well managed."*
>
> *"Have we really thought how to do it in practice ? Or shall we start thinking what should be done at the moment when the whole project is got?"*

Illusion of the common approach

This category deals with prevailing imaginings of the common proposal work and common proposal. Six projects are put together to form a proposal of one entire production line. In some disciplines common for all projects the proposal preparation has been done according to common instructions and approach. Our evidence suggests that this gives a misbelieve of a totally common approach in the sales work as can be noted from the following citations.

> *"We have not striven to have common strategy, common schedules and common basic for estimation. This is a huge contradiction: we work in divisions and then we assume that we have suddenly somehow optimized concept. We have not been asked to think about the execution and management of the project network."*
>
> *"We have 5-6 separate proposals and then we think that we are quoting one entire project."*

In the divisions it is viewed that some parts of the proposals are prepared based on common principles and by common nominated sales persons. These common procedures make divisions to envisage the package of proposals being optimized and created based on a common strategy. The illusion of the common approach is present in all areas of sales preparation from conceptual design to the risk management.

No formal structure of the common approach

Formal structure of the common approach refers to the organizational form of proposal work. As divisional approach is prevailing in the proposal preparation work it is obvious that this is the result of the lack of structured common way to perform the proposal work. The person responsible for the coordination and in some extent the synchronization of the project main schedule out of the individual project schedules forming the project network has a perspective over the whole network. The following quotations of his interview emphasis the lack of project network organization structure and optimizing perspectives.

> "*We do not have any level in the top with resources and interests. If we had a division called " project network " we would have an organization with power and we would get benefits of the optimization of the project network. "*
>
> *" In the sense of project management we have not done this work [optimizing of the whole proposal] because it was not asked in the request of inquiry and our company has not seen it necessary to be done in reserve."*

The latter quote indicates the lack of formal structure in respect to project management approach. We found various indicators which show that this is not the case in some other disciplines where formal structure and common instructions exist. Generally the lack of the formal structure of the project network can be seen as a lack of power and authority to make strategic decisions of proposal making practices and principles including risk management procedures.

No specification of the responsibilities

This category deals with responsibilities of the project network actors. Structured way of perform the work is related to responsibilities as well as to power and authority. Without a clear structure of the project network there are not specifications of responsibilities with regards to decision making power. The coordinator of one discipline puts this to words as follows.

> *"We have to understand in the divisions that we have to give power and responsibility to the umbrella organization. And then it will do the job."*

”Particularly these interfaces [to schedule of discipline] should be defined. I could give more powerful instructions or state requirements concerning time frames. But I do not know these time frames, if nobody tells me.”

We found evidence that the project execution functions could be carried out more efficiently if responsibilities of the disciple representatives would be more accurately specified. This is valid also in respect to the risk management.

Lack of common targets

The category of common targets is related to target setting level in the proposal preparation work. When common target setting is missing it is very difficult to work for it. Harmonizing and synchronizing functions in the proposal preparation aim to well organised and formally similar proposals but when common target setting is missing the optimizing is done only in the single project level. Our data reveals that a missing target setting is considered as a missing vision of the proposal work outcome depicted in the following quote. Risk management process is one of the proposal preparation processes also suffering from the missing common targets.

“We do not have clear picture in either the perspective of organizing or thinking what it is to work for the common proposal and to what it could result in.”

Coordinating mechanisms in the organization

The data analysis revealed many indicators of supporting mechanisms that served as enablers for the network level risk management in the case project. The proposal work started individually in the divisions but soon the coordinating functions were included to the process of the proposal work. Some disciplines had nominated persons to prepare a proposal of the whole discipline separated from the proposal prepared by the divisions. The proposal work had the proposal coordinator who was involved in the previous project which had similar features with this project in respect to the country of the site, scope of supply and project network structure In addition, there was a separate proposal director who guided the proposal work. Proposal coordinator and proposal director conducted several group meetings sharing common guide lines of the proposal works as well as information inside the global proposal team. Based on our data analysis the coordinating mechanisms identified in the sales phase can be categorized into three following categories.

1. Competent and experienced persons in the role of integrators
2. Group meetings
3. Information sharing (common practices, mainly informal)

Competent and experienced persons in the role of integrators

This category emphasizes the personal competence and experience of the persons nominated to act in the coordinating and integrating positions in the proposal work. Although this network project proposal differs from the typical proposals prepared by the case company, case company has delivered one project with a same kind of approach to the same country of the site. In the sales team of the whole project network there were a couple of assigned integrators securing the interrelations between divisions during the proposal work. Our analysis proposes that the proposal director, proposal coordinator as well as a coordinator of the schedules worked as integrators also in relation to the risk management perspective. The experience in organization was utilized in this proposal work by nominating to the sales team persons, who had been involved in the previous project. Proposal coordinator who is personally experienced in the mentioned area of business was nominated to the sales work as the main coordinator. We observed that most of the interviewees named the project coordinator by name referring to his personal competence and experience. The coordinator of one discipline describes his own role of integrator as follows.

> *"In the previous project I coordinated the AEI discipline. In this case as in the previous project I put one AEI coordinator to the organization. "*

Group meetings

This category devotes focus on the practical tools of coordination in the format of meetings from the viewpoint of risk management. Proposal preparation is a team work by it´s nature. This aspect is emphasized in the sales phase of the project which consists of several proposals prepared simultaneously to one end customer having purpose to build an entire new production line. In the lifecycle of the sales phase there were many coordinating meetings and working meetings. During the preparation of the case proposal there were many group meetings conducted by the proposal director and the proposal coordinator. One discipline coordinator describes one group meeting as follows:

> *" On August we had a review meeting of the whole scope of the proposals. The meeting was conducted by proposal director and proposal coordinator. All responsible sales team leaders were present. And also I and my colleague were present as responsible persons of our own disciplines.. The meeting lasted two days and we finalized the whole package. After that we gave the price to the customer."*

Information sharing

Information sharing category of coordinating mechanisms of risk management covers formal and informal information sharing methods and practices carried out during the proposal work. Our analysis of the interviews indicates that during the proposal preparation there was much information sharing between the sales team members. Information sharing was partly formal having memos, lists, tables and servers as tools. Furthermore, information sharing had also informal features consisting of email-messages and

conversations beside the coffee machine and around the lunch table. Coordinator of one discipline told how he shared information in practice in his proposal work to enhance the project success.

> *" When I read the standards of my discipline and noticed some mechanical issues there I added those to our deviation lists. Then I told to the sales guys that – Hi, are you willing to struggle for these or not."*

In the area of standards the information sharing is vital to ensure good premises for the project execution. Quotation of the interview of the sales manager illustrates the importance of coordination related to the common customer standards in the sales phase.

> "*If one division accepts one of the requirements given in the standard and another does not mention this issue at all and the third one tries to get the deviation to the requirement it is obvious that in the end the customer preferred approach will prevail."*

DISCUSSION AND CONCLUSIONS

The results of this study contribute to research on risk management in project networks. In this paper barriers and enablers for the implementation of risk management in the sales phase of the project to be executed with an internal project network structure were empirically studied. Five categories of the barriers were identified. These five categories are strict divisional approach, illusion of common approach, no formal structure of the common approach, no specification of the responsibilities and lack of common targets. The studied project based company has long history and strong tradition of performing single projects to the end customer. The cases of such project networks where several divisions are involved are rare. We found strong evidence of the dominating divisional approach of the risk management in the case project network sales phase. Proposals are prepared in the divisions and the project network proposal is combined of the individual proposals. Risk management is performed according to the divisional practices and the project network risk management can be seen as a summary of the risk management of the divisional risk managements.

However, coordinators of the proposal work gave some guide lines of proposal preparation. The role of coordinators was observed as a coordinating mechanism but simultaneously it gave an illusion of an optimized proposal prepared according to common approach. Some disciplines of proposal preparation were carried out with the common structured approach. In these areas the project network proposal is seen as a proposal prepared according to common instructions and common approach. This kind of appearance of coordination also gives misbelieve of totally common approach in the proposal work. Although the proposal work was partly structured commonly the study revealed that the predominant approach is the divisional one. Hence, there were no precise specifications of the responsibilities

relating to the roles of the integrators. The deeper analysis uncovers also the lack of common targets of the entire project network with regards to the risk management.

Based on evidence found on the study there are many coordinating mechanisms in the project network sales phase. Perceived mechanisms in the case project network have their origin in the personal competence and experience, formal working methods and common practices. Rules, regulators, procedures, formal information system, hierarchy and coordination by targets and goals are presented in the literature as coordinative mechanisms. Actions and events reported by interviewees showed that some of these coordinating mechanisms were present in the sales phase of the case project network. On the other hand in the case study the shortcomings of some of the coordinating mechanisms turned out to be barriers of implementing risk management efficiently in the project network level. As a conclusion, it is apparent that internal project network benefits from the network level approach on the point of view of project risk management. According to the understanding gained during this study the coordinating mechanisms are not adequate enough to enhance efficient and effective risk management in the sales phase of the internal project network but a more structured goal oriented approach is needed

Only limited attention has been paid to risk management in project network context in prior literature (Artto et al., 2008; Pekkinen, 2010). The findings of this study increase our knowledge of challenges of risk management in project networks in particular. Furthermore, by applying existing research on co-ordination mechanisms (Daft and Lengel, 1986; Galbraith, 1974) to the context of a project-based firm, the results of this study reveal different mechanisms that support risk management on the level of the project network. The findings of this research have various managerial implications. The findings of the study suggest that managers should pay attention to the potentially existing barriers that may hinder an effective risk management approach when implementing risk management on a project network level. The formulation of common risk management processes and practices, detailed definition of responsibilities and coordination roles, as well as the creation of common goals and investments in efficient information sharing practices were found to be amongst the most important actions to support efficient and effective risk management on a project network level.

The current research of the risk management of the case project network will continue. The studied sales project turned into a delivery project via successful contract negotiations. The risk management practices of the case project network during the different project lifecycle phases will be the subjects in the further research. By adopting a lifecycle perspective on the studied project network i.e. by examining the risk management practices from the start of the project to the expiring of the warranty period, a more holistic and in-depth picture of the evolution and development of the risk management practices can be created. The appearance and effects of the perceived barriers and enablers for the implementation of risk management in a project network will play a key role in the further research.

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MATERIALITY ANALYSIS FOR CSR REPORTING IN SPANISH SMEs[1]

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ABSTRACT

Most corporate social responsibility standards have not paid enough attention to implementation in small and medium sized enterprises (SMEs). Given that 99% of Spanish companies are SMEs, this study aims to propose a selection of basic CSR material issues that because of their usefulness and significance should be adapted to Spanish SMEs and their stakeholders. This study contributes to the development of a common framework for CSR reporting that makes the task of comparing and verifying information from firms easier and more objective. Additionally, this tool can be used by firms in their internal assessment processes. The selected group of issues can also be used to increase the openness of corporate information to stakeholders.
We have constructed a CSR model for SMEs that includes the most important social, environmental, and corporate governance issues. This model is useful for integrating sustainability in the management of SMEs and enhancing the management of stakeholders.

Keywords: Corporate social responsibility (CSR), Small and medium sized enterprises (SMEs), reporting, materiality, stakeholders.

INTRODUCTION

Corporate social responsibility (CSR) reporting in companies has strongly increased within the framework of self-regulation in recent years. This framework has been developed using various tools such us the international standards GRI Guidelines (Global Reporting Initiative, 2002; 2006), ISO 26000, and SA 8000; as well as specific tools and protocols. However, the majority of these international standards have not paid enough attention to the implementation of these tools in SMEs. More than 99% of the Spanish productive fabric is based on SMEs and these firms suffer certain monetary and information limitations when implementing CSR. This study therefore proposes a selection of basic CSR issues that are useful, significant, and adapted to Spanish SMEs and their stakeholders. This study contributes to the development of a common framework for CSR reporting that will make

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the comparison and verification of information provided by firms easier and more objective. Additionally, this tool can be used by firms in their internal assessment processes. The selection of issues will also make it possible to ensure that corporate information is more available to stakeholders.

The main aim of this study is to develop a proposal for helping Spanish SMEs report basic CSR issues. The developed materiality analysis is based on a literature review, expert knowledge, and a national SME survey.

As a result of the study, we propose a CSR model for SME reporting. This model includes the most important social, environmental, and corporate governance issues for SMEs. The model may be useful to integrate sustainability in the management of SMEs and improve stakeholder management and relationships. In addition, the results are important to advance CSR and sustainable development in SMEs.

The structure of this paper is as follows: the present introduction is followed by a description of the characteristic features in SME management, and the way these features influence CSR strategies. Section 3 defines the research design. The results of the study are analysed in Section 4. The final part of the paper presents the main conclusions of the study.

CSR MANAGEMENT AND REPORTING IN SMES

CSR can be defined as an aggregate of the voluntary policies and subsequent management processes arising from corporate decisions aimed at achieving actions in the field of economics, environment, social development, and corporate governance (Muñoz et al., 2009). Consequently, CSR may be considered as an organisational instrument for implementing the concept of business sustainability (European Commission, 2002).

Although there many academic articles related to the integration of CSR in companies, research on the implementation of CSR in SMEs is still in an early stage (Battaglia et al., 010; Rivera-Lirio and Munoz-Torres, 2010). As Morsing and Perrini (2009) indicated: '*although it is much more complex to identify, investigate, and communicate CSR in the small business, we believe this area deserves more attention due to its potential impact on the global economy*'.

In terms of CSR management, there seems to be considerable consensus that significant differences exist in the way SMEs and large companies approach and integrate CSR strategies (Jenkins, 2006). Table 1 shows the distinguishing elements of CSR in SMEs.

Some of the principal issues associated with the management of CSR refer to transparency and accountability. In recent years, the publication of sustainability reports has been established as the main mechanism for CSR reporting and is used by companies to communicate with their stakeholders and explain strategies and outcomes in terms of sustainability and CSR (Etxeberria, 2009).

Table 1. CSR in SMEs: some distinguishing elements.

Definition of CSR	**Obstacles/limits and issues to be developed**
- Difficulty understanding the concept of CSR - Concept seen as distant, possibly inoperative, or counter-productive - Activities performed seen as positive for the company and for a wide variety of interest groups - Company ethical values - Should be integrated in all elements of the business - Goes further than shareholder interests and creation of employment - Certificates used as a variable proxy for defining CSR - Participation in business organisations or openings to the public - Importance of character and values of company founders - Use of informal CSR policies	- Anxiety that activities undertaken will be seen as efforts to gain publicity and some SMEs prefer not to communicate their activities in these areas - Consider that there is information about CSR, but insufficient practical and financial aid - Consider that public authorities are not doing enough - In general, social practices are not communicated. Some internal diffusion and external diffusion in company's area of influence - Not enough time - Planning horizon is short-term - Fear of making errors during implementation of social and environmental policies - Lack of human, technical, and organisational resources

Source: (Battaglia et al., 2010; Jenkins, 2006; Murillo and Lozano, 2006; Muñoz et al., 2009; Roberts et al., 2006)

Given the distinct characteristics of these businesses, new tools for defining and communicating CSR strategies are being generated that are specifically aimed at small businesses. Various studies have emerged that aim to facilitate the production of sustainability reports by SMEs. Examples include GRI and EMS-key. GRI has developed a guide for SMEs termed 'Five Steps' and the principal aim is to help SMEs improve transparency in sustainability and CSR in the same way as has occurred with many large companies.

However, as Nielsen and Thomsen (2009) remarked CSR communication in SMEs is still at an early stage. Interestingly, authors such as Fassin (2008) consider that these published reports do not reflect 'real' CSR and that this kind of formalisation may even be counter-productive. CSR communication in SMEs is sometimes perceived as informal while personal relations are seen as being very important – yet this vision of CSR communication in SMEs ignores the importance for SMEs of corporate communication, reputation, and stakeholder relations (Nielsen and Thomsenn, 2009). This point is reinforced by the fact that SMEs are increasingly dealing with companies that operate worldwide in a competitive and complex business environment (Parsa and Kouhy, 2008).

Therefore, in light of the peculiarities of CSR in small companies, our aim has been to create a set of key CSR issues that are highly material and relevant for Spanish SMEs and their stakeholders. We have constructed a CSR model for SMEs that includes the most important social, environmental, and corporate governance issues. This model will be useful for integrating sustainability into SME management and reporting; as well as improving the management of stakeholders.

RESEARCH DESIGN

One of the aims of our research was to gain an understanding of which issues related to the management of CSR are of greatest relevance or materiality for Spanish SMEs. According to GRI (Global Reporting Initiative, 2006) materiality implies indicators and information regarding the significant social, environmental, and economic impacts of a company; or information that may have a substantial influence on the assessments and decisions of interest groups. In addition, GRI (Global Reporting Initiative, 2006) defines relevance as the degree of importance attached to each issue, indicator, or item of information – and the term refers to the threshold at which information becomes sufficiently important to be disclosed.

Our materiality analysis is based on a knowledge extraction process that is divided into the following steps: i) development of an initial draft of the main CSR material issues (based on a review of the literature) followed by an expert review; ii) a telephone survey of 500 Spanish SMEs aimed at establishing a consensus on the indicators that were not be agreed in the first step; and iii) an analysis of the results of the survey and the preparation of a proposal regarding basic CSR issues for Spanish SMEs.

The research method used in the first step combines scientific evidence with consensus. The goal was to make an initial selection of the basic CSR indicators in SMEs. Those indicators for which no consensus was agreed were then evaluated by the SMEs themselves in a survey. The RAND Appropriateness Method methodology -used in knowledge areas such as health sciences (Gonzalez et al., 2009)- has been specifically simplified and adapted for the study. As indicated by Campbell et al. (2002), the RAND method '*is a formal group judgement process which systematically and quantitatively combines expert opinion and scientific (systematic literature review) evidence by asking panellists to rate, discuss, and then re-rate indicators.*' It was considered that the RAND method was an appropriate methodology and adaptable to the study. This decision was made because, as in the case of the process of developing quality indicators in health care described by Campbell et al. (2002), a definition of material CSR issues for SMEs should take into account a number of points: i) the stakeholder perspectives of the issues; ii) the nature of the issue to be measured; and iii) the available evidence.

Under this premise, the study was divided into several sub-phases: i) an analysis of the literature on CSR tools and CSR studies in SMEs in order to create an initial set of social, environmental, and corporate governance issues; ii) a study and evaluation by a group of experts of an initial proposal for CSR material issues; and iii) discussion aimed at reaching a consensus with a group of experts on the results of the initial consultation.

After this first part of the investigation, an initial proposal regarding the material CSR issues for Spanish SMEs was obtained. Indicators that were agreed to be important by all of the experts were included in a questionnaire for a telephone survey of 500 Spanish SMEs. The development of this part of the research deepened our understanding of the perception that SME managers have regarding CSR management (Fassin, 2008).

The final stage of the investigation focused on an analysis of the results of a telephone survey and the creation of a model for CSR reporting by SMEs. In this model, the most important social, environmental, and corporate governance issues for SMEs were included. The model will be useful for integrating sustainability in the management of SMEs and improving the management of stakeholders and relationships.

ANALYSIS OF RESULTS

First part: scientific evidence and expert group consensus

As a first step, we made a thorough analysis of various tools used for CSR and sustainability management in SMEs. In parallel, we also used the results of previous research undertaken by the team that was related to the subject (Escrig et al., 2010; León et al., 2010; Muñoz et al., 2009; Rivera-Lirio and Munoz-Torres, 2010). As a result, we identified a number of potentially relevant stakeholders in the field of SME – employees, society, customers, corporate governance, environment, and suppliers – and a set of issues related to the socially responsible management of these stakeholders (Annex I).

As a next step, we relied on the support of a group of business experts whose experience would help ensure the suitability of the questionnaires before beginning the survey. To achieve this aim, we conducted a study of the materiality of the issues selected for inclusion in the survey that was based on the opinion of these experts.

The work with the expert group took place in late 2010 in two stages:

Stage 1. Compiling the expert opinions

During this stage, we contacted a group of qualified experts. The group members completed and returned the questionnaire we had developed. The questionnaire was intended to determine the materiality of a set of general issues regarding corporate social responsibility. The materiality of each issue was determined using five parameters (Lydenberg et al., 2010):

- **Financial performance and/or economic-financial risks:** Degree of importance or influence of the issues on economic performance and company risks.
- **Competitive position and strategic expectations:** Degree of strategic importance for the company and/or the perceived importance that the competition attaches to the issues.
- **Interest groups:** Degree of importance that the management of the issue may have on the decisions of interest groups.
- **Future regulations:** The likelihood of the issue being regulated in the future, and so offering the opportunity to obtain a strategic advantage by anticipating such regulation.
- **Opportunity for innovation:** Degree to which knowledge held by the company and/or its abilities may foster innovation as a result of managing this issue.

After collecting the questionnaires completed by the experts, we studied the materiality of the issues using statistical analysis – with averages used as a measure of importance and typical deviation as a measure of consensus. This subsequent analysis enabled us to establish a classification of the issues raised into two groups:

- **Issues that are clearly material:**
  - Development of products that are beneficial from a social environmental/perspective
  - Stable employment
  - Pollution, effluents, and waste
  - Training and education / professional development
  - Investment in environmental R & D + i / clean technology
  - Marketing
  - Client satisfaction
  - Product safety / health and safety of clients
  - Health and safety at work / working conditions

- **Issues of doubtful materiality:**
  - Product cycle management
  - Resource use
  - Transparency and communication
  - Evaluation and monitoring
  - Hiring practices / local hiring
  - Codes of conduct
  - Social action
  - Director salaries
  - Recycling
  - Environmental management systems
  - Compliance with regulations
  - Cooperation with local industries
  - Managing the interests of shareholders
  - Customer privacy
  - Sustainable behaviour among clients
  - Local community / local development
  - Reconciling work and family life
  - Discrimination / diversity and equal opportunities
  - Education and environmental awareness
  - Labelling of products and services
  - Freedom of association and collective bargaining
  - Transparency
  - Nature and biodiversity
  - Harassment
  - Unfair competition
  - Corruption and bribery
  - Rights for ethnic minorities
  - Forced labour and child exploitation

Stage 2. Work session with experts

We then met the expert panel to analyse and discuss the results of the previous stage and reach consensus on a classification of the issues.

During the discussions, special attention was paid to those issues whose materiality was not agreed by the various experts ('issues of doubtful materiality'). The experts argued the reasons for their classification, discussed the ratings assigned to each of the parameters of evaluation, and compared their values with those of other experts. During the process of reflection, the experts reconsidered their positions regarding the materiality of various issues considered as doubtful and so several issues were reclassified as being clearly material (see Table 2). The results of this discussion enabled us to design a questionnaire that was used in the telephone survey.

Table 2 reveals that corporate governance and supplier management are not important issues with respect to CSR management in SMEs. The reasons given in the case of corporate governance focused on the small size of the shareholdings in this type of business and the concentration of ownership and control – as well as the absence of formal mechanisms for structuring control systems.

The reasons for not including supplier management in the analysis of CSR were varied and reflected the bargaining power of small companies. Either the power of a small company to establish conditions is very limited, or small companies face oligarchic market structures in the supply of raw materials, and these factors prevent them from establishing mechanisms for selecting suppliers.

Table 2: Issues that the expert panel believe to be clearly material.

Stakeholder	**CSR Issue**
Customers	Development of products that are beneficial from a social/environmental/perspective
	Marketing
	Client satisfaction
	Product safety/health and safety of clients
Environment	Pollution, effluents, and waste
	Investment in environmental R & D + i / clean technology
	Resource use (energy, water, materials)
	Recycling
Society	Local community/local development
	Cooperation with local industries
	Transparency and communication
Employees	Stable employment
	Training and education/ professional development
	Health and safety at work/working conditions
	Reconciling work and family life
	Discrimination/diversity and equal opportunities

Part Two: Development and implementation of a telephone survey of 500 Spanish SMEs

From the meeting with the expert panel, it was concluded that it was necessary to translate the issues into practical questions that could be handled in the time available for the telephone survey and be easily understood by the respondents. A key aspect when developing a questionnaire is the wording of the questions: the objective being not discover to what extent the company has implemented CSR policy – but to discover the importance

that the company management attaches to the issue. The survey was therefore aimed at managers or directors of small companies.

The survey was conducted during the third quarter of 2010 and some 502 SMEs with between 10 and 200 employees were contacted. The firms operate in the following sectors: food and agriculture, industry, construction, and services – and all the Nielsen areas were taken into account. The survey included a total of 29 questions that were associated with the preparation of annual reports in the widest sense; as well as social and environmental information related to various stakeholders (suppliers, customers, shareholders, the environment, employees, and society).

Part Three: Analysis of survey results and proposed material CSR issues

Analysis of survey results

After conducting the survey and processing the results we drew some preliminary conclusions that are shown in Figure 1. The figure illustrates average and standard deviation of responses to survey questions. The labels correspond to the numbering system for the questionnaire. In Tables 3, 4, and 5, the first column refers to the stakeholder involved in the issue; and the second column shows the question used for each issue.

1. It is worth noting that none of the issues under evaluation is immaterial or irrelevant as the minimum average score was 3.49 (minimum 1, maximum 5).
2. There is considerable consensus on the issues most highly rated. However, in zones with lower scores, there is little consensus and there are major discrepancies between business managers regarding the importance of these issues. As a result, no issue can be out excluded a priori as immaterial.
3. We can define three zones of evaluation for the various issues raised in the survey. These zones are defined by the average deviation values found in the responses received. We have established the following zones of analysis in order of the most-to-least importance as given by the respondents: A, B, and C.
4. An analysis of the issues evaluated in Zone A (Table 3) reveals that there is little consensus and a generally low evaluation of the importance of issues linked to corporate governance and supplier relationships. It can also be seen that the issues in Zone A clearly correspond to CSR issues covered by the national legal framework and international standards.

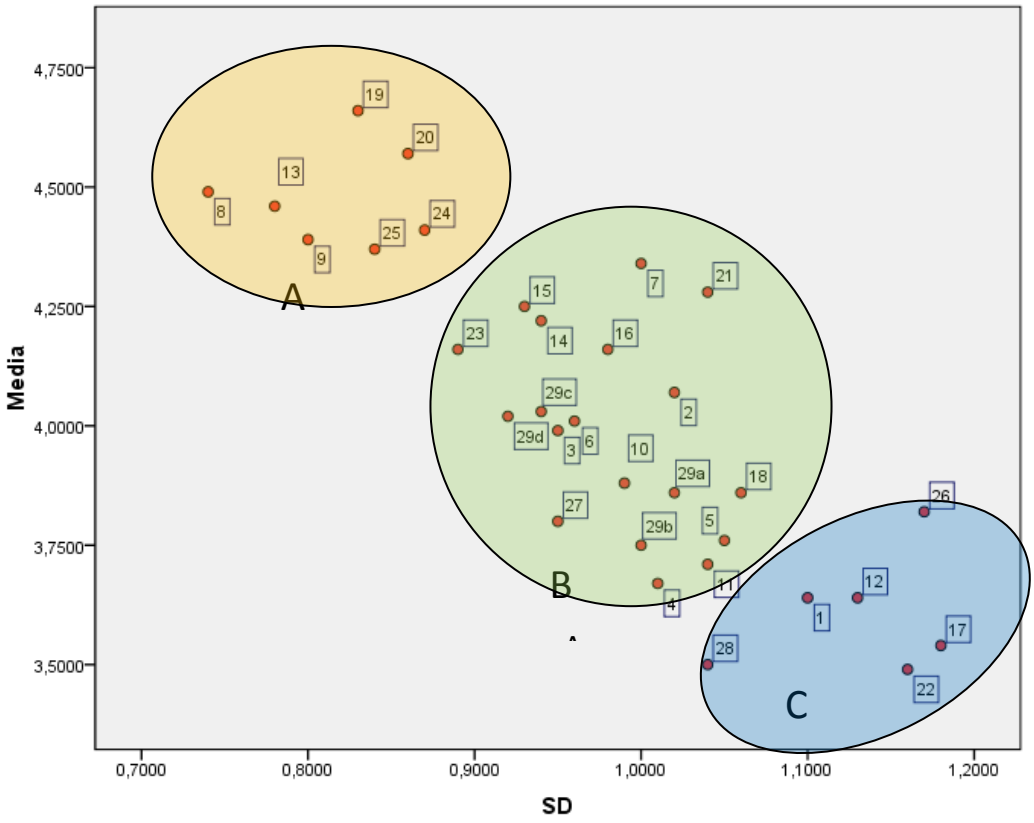

Figure 1: Average deviation analysis of the survey results

Table 3: Issues in Zone A.

Stakeholder	Code	CSR issue
Customers	8	Customer privacy
	9	Compliance with regulations
Environment	13	Nature and biodiversity
Society	25	Unfair competition
	24	Corruption and bribery
Employees	19	Forced labour and child exploitation
	20	Harassment

5. Within Zone B (Table 4) there are issues relating to all stakeholders with the exception of 'society'. The majority of these issues are directly related to managing the supply chain. It can be clearly seen that there is consistency in the responses to the questions that are closely related, such as those questions regarding a code of conduct for dealing with suppliers.

Table 4: Issues in Zone B.

Stakeholder	Code	CSR issues
Customers	10	Sustainable behaviour among clients
	7	Labelling of products and services
	23	Compliance with regulations
Corporate governance	11	Managing the interests of shareholders
Environment	15	Product cycle management
	14	Environmental management systems
	18	Education and environmental awareness
Suppliers	3	Evaluation and supervision
	2	Hiring practices
	4	Codes of conduct. Social and environmental commitments
	6	Codes of conduct. Stable relation with suppliers
	5	Hiring practices / local hiring. Sustainable behaviour with clients
Employees	21	Discrimination / diversity and equal opportunities
	16	Freedom of association and collective bargaining

6. Most of the issues in Zone C (Table 5) are related to the 'society' stakeholder. Question 1 regarding the importance of reporting on social and environmental issues in the annual accounting report, or other voluntary reports, has been rated with an average of 3.64 (minimum 1, maximum 5). This is a relatively low score and there is also considerable dissent. A possible explanations for this result may be that SME managers consider other uses of this information to be more important in relation with stakeholders – given that dissent is less and evaluations are higher when the information is focused on generating specific advantages for a company: such as improvements in economic performance; market position in comparison with the competition; strategic advantage relative to future regulation; and opportunity for innovation.

Table 5: Issues in Zone C.

Stakeholder	Code	CSR issue
Corporate Governance	12	Director salaries
Suppliers	28	Hiring practices / local hiring
Society	1	CSR information. Transparency and communication
	17	Social action. Corporate voluntary work
	22	Social action. Donations.
	26	Minority ethnic rights

Proposal regarding material CSR issues for SMEs

After an analysis of the results, Tables 6 and 7 contain the final proposal of issues considered as material for Spanish SMEs.

Table 6 lists the 23 issues considered as 'key' for a proper management and communication of sustainability in SMEs – as identified by their positioning in Zone A following the survey. This selection of major issues excludes managing the relationship with suppliers and organisational governance.

The management of these two stakeholders was considered immaterial by the expert group and this assessment was confirmed by the results of the survey.
Following the completion of the session with the group of experts and the subsequent survey, an analysis of the results enabled a pruning of the issues proposed in the first stage of the investigation.

Table 6: Core material issues.

Stakeholder	**CSR issue**
Customers	Development of product benefits that are beneficial from a social environmental/perspective
	Marketing
	Client satisfaction
	Product safety / health and safety of clients
	Client privacy
	Compliance with regulations
Environment	Pollution, effluents, and waste
	Investment in environmental R & D + i / clean technology
	Resource use (energy, water, and materials)
	Recycling
	Nature and biodiversity
Society	Local community / local development
	Cooperation with local industries
	Transparency and communication
	Unfair competition
	Corruption and bribery
Employees	Stable employment
	Training and education / professional development
	Health and safety at work / working conditions
	Reconciling work and family life
	Discrimination / diversity and equal opportunities
	Forced labour and child exploitation
	Harassment

The high average values scored for the other issues raised in the survey, and the lack of consensus among experts regarding their materiality, are a positive factor when proposing additional information structures to be considered by companies that, because of their specific characteristics, may need to disclose information covering all stakeholders.

Table 7: Complementary/additional material issues.

Stakeholder	CSR issue
Customers	Compliance with regulations
Employees	Discrimination / diversity and equal opportunities
	Freedom of association and collective bargaining
Customers	Sustainable behaviour among clients
	Labelling of products and services
Corporate Governance	Managing the interests of shareholders
	Director salaries
Environment	Product cycle management
	Environmental management systems
	Education and environmental awareness
Suppliers	Evaluation and supervision
	Codes of conduct
	Hiring practices / local hiring
Society	CSR information. Transparency and communication.
	Social action
	Minority rights

CONCLUSIONS

The amount of information that the expert panel and survey have generated has enabled us make an analysis of the perception of sustainability held Spanish SMEs – and its impact on management and the disclosure of information.

An analysis of materiality for Spanish SMEs provides information on the perception that these companies have of sustainability and the impact of sustainability on business management, as well as the disclosure of information regarding social, environmental, and corporate governance.

The study was conducted following a review of the CSR norms and standards that are most widely accepted by academic and professional experts; as well as a survey of 500 Spanish SMEs.

The results reveal that Spanish SMEs attach great importance to the correct management of 23 basic issues relating to customers and employees – as well as the environment and society in general. In addition, some 16 other additional issues of lesser materiality for smaller SMEs were also identified; and these issues were mostly related to corporate governance and supplier management.

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ANNEX I. DESCRIPTION OF AREAS INITIALLY IDENTIFIED

	Issue	Description
Employees	***Stable employment***	Job security in the workplace through permanent employment contracts and activities to promote staff cohesion and a sense of belonging.
	Freedom of association and collective bargaining	Right of employees to join and form groups with legitimate aims, and to be represented by independent trade unions.
	Training and education / Professional development	Ongoing employee access to training to enable them to improve their job and/or social skills, as well as guarantees of personal and professional development in the company.
	Reconciling work and family life	Flexible schedule, telecommuting option, flexible leave of absence, flexibility for family care, aid for child care, school support, health insurance, life and/or accident insurance, risk prevention measures beyond the mandatory, etc.
	Health and safety at work/working conditions	Safe environment and working conditions appropriate to the tasks being performed. Risk prevention plans, as well as resources necessary for the proper management of work accidents.
	Forced labour and child exploitation	Policy against child labour and forced labour, as well as related procedures and programs. Report on monitoring systems and results.
	Harassment	Prevention of workplace bullying with policies and procedures to prevent employee harassment.
	Discrimination/diversity and equal opportunities	Fair pay and equal opportunities for advancement and improvement, regardless of sex, disability, or other criteria.
Society	***Rights for ethnic minorities***	Policies, guidelines, and procedures to manage the needs of ethnic minorities.
	Local community/local development	Measures to encourage the relationship with the community – such as attending meetings for community issues, training for people in the community, transfer of facilities for community use, purchasing of local products, etc.
	Corruption and bribery	Policies and management systems and compliance mechanisms related to corruption and bribery – aimed at the company and employees.
	Transparency and communication	Published information on policies and outcomes regarding sustainability.
	Cooperation with local industries	Cooperation with local companies to benefit the economic, social, and/or environmental community.
	Unfair competition	Prevention of conduct that is contrary to free competition by implementing policies, procedures, and suitable management systems.
	Social action: donations, philanthropy, voluntary work, sponsorship	Encouragement of volunteering among employees, support for stable economic sponsorship, and support for employment by groups that encounter problems finding jobs, etc.
Clients	***Product security/health and client safety (product impacts)***	Policies, practices, and procedures to evaluate and analyse the impacts of products on the health and safety of clients.
	Labelling of products and services	Suitable labelling that provides relevant information for the customer and assists their buying decisions.
	Marketing	Honest promotional activities and sponsorship appropriate to the company's strategic objectives – as well as activities promoting

		sustainability and management of social and environmental issues.
	Client privacy	Suitable treatment of personal data on clients.
	Compliance with regulations	Strict enforcement of the most restrictive legal framework that is applicable to the company according to its activities and location(s).
	Sustainable behaviour among clients	Establishment of policies and practices that encourage clients to behave in a socially responsible manner.
	Client satisfaction	Policies and practices to increase client satisfaction / wellbeing / quality of life.
	Development of product benefits that are beneficial from a social environmental/perspective	Product development and/or services that encourage sustainable development.
Governance	***Transparency***	Policies, practices, and procedures to ensure that information provided to governing bodies is useful and accurate.
	Managing the interests of shareholders	Policies and practices to defend the rights of shareholders – such as voting rights and information.
	Director salaries	Pay and reporting policy.
	Review panels	Review panels established in the governing bodies to ensure the proper functioning of various processes, business units (special emphasis on CSR panel), and other elements of the company.
Environment	***Resource use (energy, water, and materials)***	Control procedures and management of resources employed, savings plans, recycling, etc.
	Pollution, effluents, and waste	Control and management of pollution, and waste resulting from the business, traceability of origin and destination.
	Product cycle management	Management of main environmental impacts of products and services during life cycle.
	Recycling	Policies for recycling resources consumed.
	Investment in environmental R & D + i / clean technology – Eco-efficiency	New cleaner product design and implementation of clean technologies.
	Environmental management systems	Environmental management systems for the management of environmental impacts, as well as disaster prevention and appropriate response to accidents.
	Education and environmental awareness	Actions to raise employee awareness.
	Nature and biodiversity	Corporate action with respect to their impacts on living beings and the environment.
Suppliers	***Codes of conduct***	Codes of conduct with suppliers to specify criteria beyond the strictly economic and ensure long-term business relations.
	Evaluation / supervision	Awareness that suppliers must comply with tax laws and labour contracts and set minimum standards. Mechanism to detect and eliminate abusive practices against suppliers.
	Hiring practices / local hiring	Selection of suppliers based on commitment to corporate social responsibility; avoidance of dealings with companies that violate the rights of workers according to the ILO (for suppliers from outside the European Union).

THE PROCESS TO DETERMINE POSSIBILITIES AND NEEDS FOR MOBILE MAINTENANCE – APPROACH TO STRENGTHEN MAINTENANCE WITH MOBILE TECHNOLOGY

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ABSTRACT

The exploitation of mobile technologies keeps on expanding, but has not become popular in heavy industry and maintenance. One of the reasons is that companies do not see the possibilities of mobile solutions in professional use because current solutions have been developed for consumers. Maintenance companies are now looking for new ways to develop working methods and tools to be more efficient and real-time. Therefore the interest for mobile solutions in professional use has increased.

This paper presents the case study where the role of mobile technology was researched in strengthening the maintenance operations. One of the aims was to research the development process of professional mobile solutions for maintenance domain. The paper presents how case study applied the Solution Envisioning Approach with Capability Cases as a process in determining possibilities and needs for mobile maintenance.

Phases of the approach were gone through by applying its steps depending on situation. One reason for the customed appliance of the approach was the goals and purposes of the case study. Instead of designing or implementing, general scientific results and information about applying mobile technology in maintenance to boost up performance were required as a result. For example several Capability Cases were developed to support efficient maintenance by exploiting mobile technologies. The cases were developed as a result of workshops arranged in different enterprises. The participants in workshops represented different levels of maintenance organizations. Overall the approach was discovered as good guideline and the developed process can be now applied by enterprises themselves.

Keywords: Process, Mobile, Maintenance

INTRODUCTION

The exploitation of mobile technologies will keep on expanding. Mobile technologies and solutions have been used in consumer applications with good results, but still they have not become very popular in heavy industry and maintenance in Finnish context. One reason is that companies do not quite see the possibilities of mobile solutions in heavy industry and maintenance operations because current solutions have been developed for consumer sector. Due to recession maintenance companies are now looking for new ways to develop working methods and tools to be more efficient and real-time therefore the interest for

mobile solutions in professional use has been increased. Mobile solutions bring maintenance management closer to the daily practice in the field and lead to more efficient maintenance operations.

The general technology acceptance models focuses to user acceptance and adoption. These kinds of models are for example TRE (Ajzen and Fishbein, 1980), TAM (Fishbein and Ajzen, 1975), TPB (Ajzen, 1991), IDT (Rogers, 1995) and UTAUT (Vekatesh et al., 2003). Available are also mobile service and technology acceptance models, like Mobile Services Acceptance Model (Gao et al., 2008) and Conceptual model of mobile service adoption (Ervasti and Helaakoski, 2010), which are developed to test user's acceptance, attitude and intention to adopt new mobile services and mobile technologies. There are also case studies (Ervasti and Helaakoski, 2010) and researches (Kaasinen, 2005) about mobile service acceptance and consumer use. When considering use of professional mobile solutions in industry and especially in maintenance the available studies and researches focus mainly on e-maintenance (Crespo-Marquez and Iung, 2008; Mullera et al., 2008). In Finnish context there are also available research and studies about e-maintenance (Jantunen et al., 2009). Some e-maintenance specific case studies focus on mobile device architectures where the mobile device can for example help the maintenance engineer to perform maintenance tasks (Campos et al., 2009). Term e-maintenance is still quite large concept where the mobile solutions can be one part of it. When considering processes or models how to determine possibilities and needs for mobile solution in industry, and especially in maintenance, there is lack of available processes, models and researches. There are still some general methods for problem discovery and solution planning. The method called Solution Envisioning Approach with Capability Cases is a problem discovery, situation assessment and solution planning process that uses Capability Cases to achieve connections between Business and IT stakeholders (Polikoff et al., 2005).

In this paper the appliance of the Solution Envisioning Approach based process to determine possibilities and needs for mobile maintenance are presented. Also the results and experiences relating to appliance are presented and possibilities to use the process in enterprises by themselves are discussed. This paper presents the mobile maintenance case study which studied the role of mobile technology for supporting the maintenance operations to be more efficient and reliable. One of the aims was to research the development process of mobile solutions that are aimed for professional use in maintenance domain. This research applied Solution Envisioning Approach with Capability Cases for developing a concept for mobile solution development in maintenance. In the case study the approach was applied in addition to technology adoption perspective. The technology adoption perspective means that the factors affecting to acceptance and adoption of industrial mobile solutions have been taken in to account in addition to following to the approaches phases.

The work presented in this paper has been conducted in the Mobile Maintenance project (Moma). The case study was performed during 2009-2010. Four different enterprises were participating to this research. The participating enterprises were from era of energy, industry, maintenance and ICT.

This Paper is organized as follows. Chapter Solution Envisioning Approach with Capability Cases presents the background and basics of the approach applied. Chapter Mobile Maintenance Case Study introduces the case study of this research. The process applied in the case study is presented phase by phase in corresponding chapter. The results are presented in the corresponding chapter Results.

SOLUTION ENVISIONING APPROACH WITH CAPABILITY CASES

In this chapter the method called Solution Envisioning Approach with Capability Cases is presented. Solution Envisioning is a problem discovery, situation assessment and solution planning process that uses Capability Cases to achieve connections between Business and IT stakeholders. It was designed to improve chances of solution success by addressing the risks and challenges present in the early stage of the solution lifecycle. Solution Envisioning embraces a business-centric approach to designing and realizing technology enabled business capabilities. Its purpose is to 'bridge the gap' between business and IT by integrating and matching concepts and techniques from both best of breed business strategy methods and software development methods. Following figure 1 illustrates the process of Solution Envisioning Approach. (Polikoff et al., 2005)

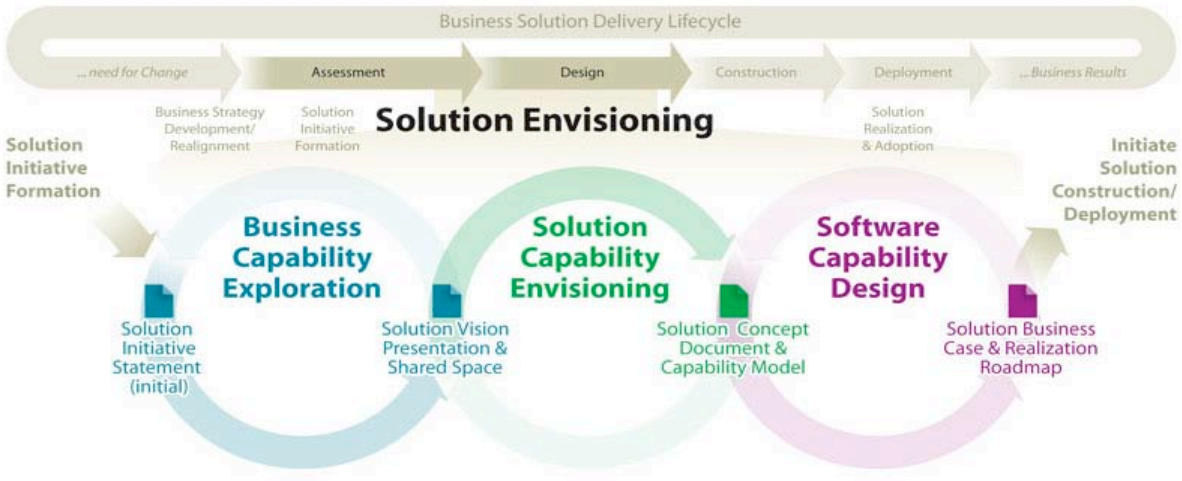

Figure 1: Solution Envisioning Approach (Polikoff et al., 2005).

Solution Envisioning with Capability Cases is designed for use at a front end of the software development lifecycle. The process can be partitioned into three major steps or phases, with the use of Capability Cases occurring throughout. The three phases of Solution Envisioning are (Polikoff et al., 2005):

1. Business Capability Exploration – BCE
   • Creating the Solution Vision and an initial Business Case

2. Solution Capability Envisioning – SCE
   • Creating the Solution Concept

3. Software Capability Design – SCD

- Elaborating and confirming the Business Case and delivering the Solution Implementation Roadmap

Business Capability Exploration – BCE

The nature of Business Capability Exploration is to do the necessary pre-work of laying the foundation for the solution. Its purpose is to establish the existing context of the business and to support a select, core-team of stakeholders who are initially driving the initiative as they produce a preliminary Solution Vision. Preliminary because it will be shared and shaped in successive phases. Following figure 1 illustrates the BCE phase. (Polikoff et al., 2005)

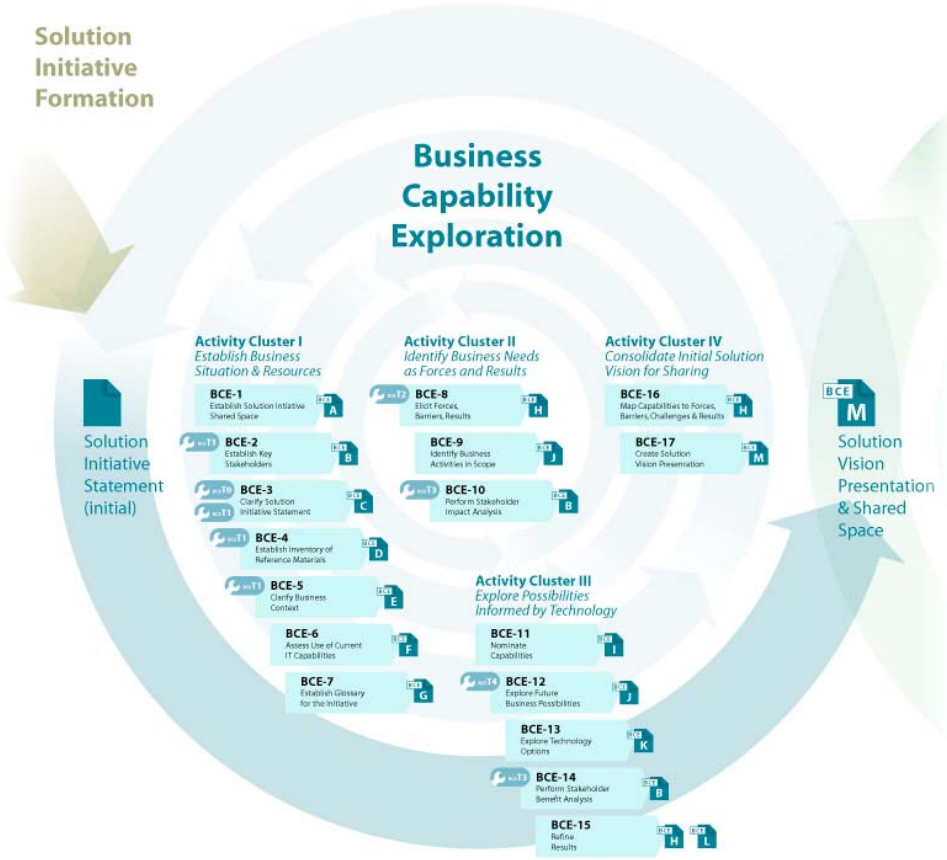

Figure 2: Phase I: Business Capability Exploration (BCE) (Polikoff et al., 2005).

To arrive somewhere new there is the need to understand where you are, what is causing the need to move and what results the move needs to achieve. Business Capability Exploration has a number of framing and focusing activities guided by these objectives (Polikoff et al., 2005):

- Assessment of business dynamics and predicaments
- Expression of root causes and their analysis – a relationship between cause and effect in the business environment

- Initial scan of potential solutions
- Agreement over business objectives

The phase is completed when an understanding is reached on the nature of business problems, the specific results the solution will need to bring about, and vision of how the solution might be realized. This understanding is documented as a Solution Vision Presentation and made available to a broader set of stakeholders within a suitable collaborative portal or workspace. (Polikoff et al., 2005)

Solution Capability Envisioning – SCE

The nature of Solution Capability Envisioning is to facilitate a series of collaborative interactions or envisioning workshops that enable a broad set of stakeholders to forge a shared understanding about the intent of the initiative and the details of the solution vision. Having understood and represented the problem in the activities of the previous phase, an exploration of solution alternatives proceeds with the confidence that there is now a framework for evaluation of proposed ideas and concepts. The purpose of this phase is to assemble solution building blocks by nominating, evaluating and prioritizing an integrated set of capabilities that will collectively meet the business goals. Following Figure 3 illustrates the SCE phase. (Polikoff et al., 2005)

Figure 3: Phase II: Solution Capability Envisioning (SCE) (Polikoff et al., 2005).

The phase is completed when the Solution Vision has been refined and confirmed by a broadly representative set of stakeholders. The result --an integrated and optimized set of capabilities sufficient to realize the business solution-- are captured and communicated in the form of a Solution Concept Document. Solutions need to be understood in terms of their effects on how people and systems will work. The Solution Concept is created through (Polikoff et al., 2005):

- Matching the problem at hand to known solution capabilities (via Capability Cases)
- Collaborative sessions to envision how solution capabilities will overcome challenges and bring about the desired results
- Story telling to establish shared understanding of the roles that the business side and technology side will play in the future world
- Arrangement of the capabilities into the various solution concept views of the conceptual architecture
- Agreement about business priorities for the implementation of capabilities

Software Capability Design – SCD

The nature of Software Capability Design work is the conversion of the results of envisioning – the Solution Concept – into an actionable set of high-level designs and plans for building the solution. Its purpose is to complete the development and documentation of a Solution Realization Roadmap. These deliverables must be sufficient to scope, fund and launch an efficient final phase for assembling, deploying and adopting the solution. Following Figure 4 illustrates the SCD phase. (Polikoff et al., 2005)

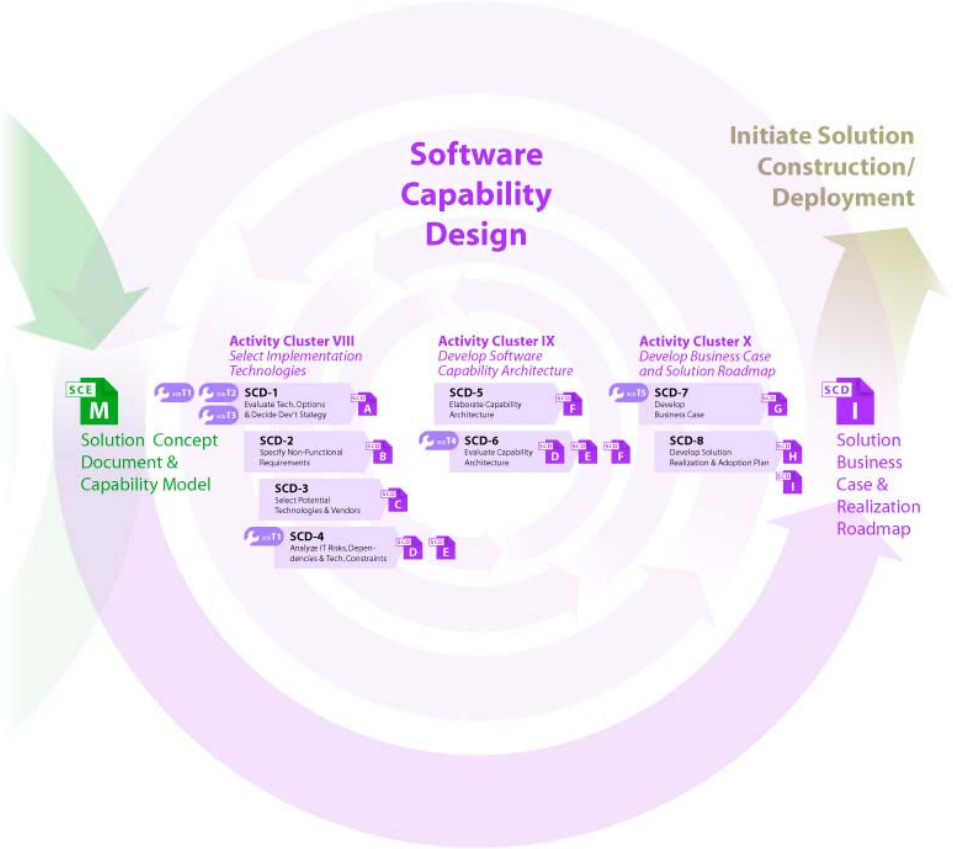

Figure 4: Phase III: Software Capability Design (SCD) (Polikoff et al., 2005).

When the capability view of the conceptual architecture has been developed, the technical components of the solution can be identified. It is at this stage that technology decisions will be made and a component or service-oriented architecture defined. The organizational impact of the solution will be understood and planned for. Priorities for implementation will guide the creation of a roadmap including a solution blueprint and plans for its realization.
In summary, the Capability Design work entails (Polikoff et al., 2005):

- Making commitments to technology decisions
- Elaborating the capability architecture of the solution
- Specifying evolvable solutions using component and service-oriented architectures
- Completing a business case sufficient to support the final development of the solution
- Creating communication and organizational change strategies
- Building a solution realization roadmap

The phase is completed when the work of Solution Envisioning has been packaged as an actionable shared memory in the organization. This means that the business goals, justification, high-level designs and plans have been clearly articulated and documented in a form directly usable in the construction phases. The construction can be accomplished in a number of ways. Whether the approach is to buy, build or both, the goal is to set the stage

for an efficient and successful realization and adoption. The Solution Envisioning deliverables are designed to provide a seamless connection to popular software engineering methods by providing the input they specify and require. (Polikoff et al., 2005)

MOBILE MAINTENANCE CASE STUDY

In this chapter mobile maintenance project, case study and process, are presented. The case study was performed in the project during 2009-2010. Four different enterprises were participating to this research performed by VTT. The participating enterprises were from era of energy, industry, maintenance and ICT. The case study researched the role of mobile technology in strengthening the maintenance operations.

The project had three major aims; firstly to identify the benefit of mobile technology in maintenance and to measure it, secondly to research the development process of mobile solutions aimed for professional use and thirdly to evaluate the potential of new technologies in developing more value added mobile solutions in industrial environment. The research was done in demanding industrial environment that will set hard requirements for mobile solutions. Therefore, the aim of this project was to develop solutions that will ease and fasten the maintenance operations in such environment. The project was researching new mobile technologies in order to provide user-friendly and convenient ways of using mobile solutions.
The project's case study experiences presented in this paper include mainly the process and appliance of it. Different stakeholders were involved in interviews and workshops to ensure different aspects and point of views to get noticed. Large stakeholder participation aimed also to better user acceptance and technology adoption since all parties were involved in the very beginning of the project. It is essential that also end users are participating to the work shops. User involvement is especially useful in the early stages of service development processes due to their high uncertainty and low formalization (Kaasinen et al., 2010).

Used process in the project was an appliance of the Solution Envisioning Approach (Polikoff et al., 2005). One of the aims was to research the development process of professional mobile solutions for maintenance domain. The paper presents how the case study applied the Solution Envisioning Approach with Capability Cases as a process in determining possibilities and needs for mobile maintenance. The applied process of the project is presented in the chapter The Process in the Case Study.

THE PROCESS IN THE CASE STUDY

In this chapter the used process applied in the case study is presented. The presentation includes mainly information about the work products and activities performed when different phases of the Solution Envisioning Approach (SE) were applied.

The process in the case study included following main activities: Specifying requirements, Technology study, Theoretical research about acceptance and adoption of industrial mobile solutions, Studying the present and future of mobile solutions in maintenance, Assessment of solution benefits, Assessment of possible solutions and creating initial solution concept, Focusing of the solution concept, Piloting the solution options and Documenting the process

of the case study. The following listing presents in more detail the main activities of the process used in the case study:

- Specifying requirements
  - Preliminary business investigation
  - Enterprise interviews
  - Specifying stakeholder requirements
  - Collecting reference materials
  - Defining business needs
  - Defining maintenance terminology used
  - Review by enterprises

- Technology study
  - Studying technologies and possibilities
  - Initial analysis about technologies for the solution
  - Review by enterprises

- Theoretical research about acceptance and adoption of industrial mobile solutions
  - Creating Industrial Mobile Solutions Adoption Model – IMSAM
  - Review by enterprises

- Studying the present and future of mobile solutions in maintenance
  - Studying the current situation and use of mobile solutions in the enterprises
  - Defining general maintenance processes used today
  - Creating initial capability cases portfolio as a result of internal workshop
  - Updating, focusing and enlarging capability cases portfolio in the enterprise workshops
  - Analyzing technology options needed for different capability cases
  - Verifying that capability cases are answering to the requirements of different stakeholder requirements
  - Visioning future maintenance processes supported with mobile solutions
  - Review by enterprises

- Assessment of solution benefits
  - Studying maintenance key figures and theories about benefits and measuring
  - Assessing the benefits of the mobile technology in maintenance domain
  - Defining how to measure benefits of mobile technology in maintenance domain
  - Review by enterprises

- Assessment of possible solutions and creating initial solution concept
  - Assessment of solution possibilities, processes and capability cases in internal workshop
  - Updating and focusing solution on the basis of assessment
  - Creating initial solution concept
  - Review by enterprises

- Focusing of the solution concept
    - State-of-art study
    - Theoretical research about solution concept including human factors
    - Collecting information about important issues needed to be noticed/handled by enterprises when implementing/taking solution in use
    - The focused solution concept and framework for mobile maintenance
    - Review by enterprises

- Piloting the solution options
    - Piloting different kind of solution options in enterprises
    - Three pilots: usability, map based resource management and possibilities of web-browser
    - Analysis of pilot experiences

- Documenting the process of the case study
    - Studying Solution Envisioning Approach and following and applying its steps according to situation
    - Documenting the appliance of approach as the process for the case study
    - Documenting the work products created as a result of the process
    - Review by enterprises

Some of the SE approach steps/phases were applied loosely or skipped depending on situation. In the case study for example it was not possible to make some specific decisions for participating enterprises. These decisions might be for example vendors, devices, roadmaps etc. In general it was possible to give information, advises, issues to be considered/noticed and research different possibilities, but not to give exact technical requirements, specifications, deadlines etc. for the product or solution.

In the following chapters the work products and activities performed are described step by step relating to different phases of the Solution Envisioning Approach (SE) applied. In addition to appliance of SE approach's steps and phases, some additional activities were considered necessary and useful. These activities were theoretical research about acceptance and adoption of industrial mobile solutions and theoretical research about human factors relating to mobile solutions and usage. In addition to this actual piloting were also performed outside the scope of applied approach.

The Activities and Work products of Phase I, Business Capability Exploration

The SE Approach BCE phase's steps 1-17 were applied as described in the following table 1:

Table 1: Activities and work products in the case study relating to BCE phase.

Step #	SE Activity Description	Applied activities	Created Work products
1	Establish Solution Initiative Shared Space	Creating shared space for information sharing and web site for marketing channel	Shared space and version control, Web site
2	Establish Key Stakeholders	Decided steering group members and named key persons	List of steering group members and key persons
3	Clarify Solution Initiative Statement	Confirmed solution initiative on the basis of enterprise interviews	Project plan and solution initiative
4	Establish Inventory of Reference Materials	Reference material gathered from enterprises and studied	Collection and inventory of Reference materials
5	Clarify Business Context	Created overall figure about descriptive value net and business environment	The model of the business environment
6	Assess Use of Current IT Capabilities	Assessment of current and piloted mobile solutions in enterprises relating to maintenance domain	Reported IT Givens relating to mobile solutions
7	Establish a Glossary for the Initiative	Common terminology between enterprises collected and listed	Terminology listing
8	Elicit Forces, Barriers, Results	On the basis of enterprise interviews defined three what's: Forces, Barriers and Results	Tables of Forces Barriers and Results
9	Identify Business Activities in Scope	Created general maintenance process diagrams about today's situation on the basis of reference materials from enterprises	General maintenance process diagrams today
10	Perform Stakeholder Impact Analysis	Created Business Capability Model on the basis of forces barriers and results	Business Capability Model
11	Nominate Capabilities	Created initial capability cases portfolio as a result of internal workshop	Initial capability cases portfolio
12	Explore Future Business Possibilities	Updated, focused and enlarged capability cases	Capability cases portfolio

		portfolio in the enterprise workshops	
13	Explore Technology Options	Performed technology mapping and defined needed mobile technologies and options	Technology study, mapping and tables about needed/possible technologies/ technological options
14	Perform Stakeholder Benefit Analysis	Analyzed how different stakeholders requirements/expectations are met by relevant capability cases	Tables about stakeholder different stakeholders' requirements and relevant capability cases
15	Refine Results	Defined measures for benefits/results	Tables about measures for the results
16	Map Capabilities to Forces, Barriers, Challenges, and Results	Assessment of benefits in the Business Capability Model	Diagrams about the benefits and tables about the capability cases supporting defined requirements and goals
17	Create Solution Vision Presentation	Conclusions and presentations made on the basis of previous steps	Conclusions documented and presentations

The Activities and Work products of Phase II, Solution Capability Envisioning

The SE Approach SCE phase's steps 1-17 were applied as described in the following table 2:

Table 2: Activities and work products in the case study relating to SCE phase.

Step #	SE Activity Description	Applied activities	Created Work products
1	Envisioning Workshop Planning	Planning workshop	Workshop plans
2	Elaborate Capability Cases Portfolio	Preparing capability case portfolio for the workshop	Prepared capability cases
3	Conduct Pre-Envisioning Workshop Walkthroughs	Searching evidence about Business Situation and Possibilities. Performing State-of-art study.	State-of-art presentation
4	Preparing for Capability Cases Gallery	Preparing capability cases for the work shop	Prepared capability cases
5	Launch Solution Envisioning Workshop	Envisioning workshop	
6	Review Solution Vision	Envisioning workshop	Reviewed solution vision
7	Envision Solution Possibilities	Envisioning workshop	Capability cases score cards
8	Conduct Solution Scenario Enactment	Envisioning workshop	Capability cases and future process diagrams
9	Prioritize Capabilities	Envisioning workshop	Prioritized capability cases
10	Assess Solution Realization Gap	Envisioning workshop	Capability cases realization gap. Needed technologies and technology options
11	Conduct Post-Workshop Analysis and Consolidation of Concepts	Envisioning workshop and conclusions	Initial Solution Concept and its framework

The Activities and Work products of Phase III, Software Capability Design

The SE Approach SCD phase's steps 1-8 were applied as described in the following table 3:

Table 3: Activities and work products in the case study relating to SCD phase.

Step #	SE Activity Description	Applied activities	Created Work products
1	Evaluate Technology Options and Decide Development Strategy	Evaluation of Technologies Software/product development principles	Documented listing of technologies needed for development strategy
2	Specify Non-functional Requirements	Presenting information about Non-functional Requirements	Basic information about non-functional Requirements
3	Select Potential Technologies and Vendors	Researching and collecting information about selecting and implementing: vendors, products, services, training, support, deployment, maintenance and continuous development	Documented information about selecting and implementing: vendors, products, services, training, support, deployment, maintenance and continuous development
4	Analyze IT Risks, Dependencies, and Technology Constraints	Analyzing SOA architectures and collecting general information about risks and risk management	General information about SOA architectures and risk management
5	Elaborate Capability Architecture	Considering SOA options	Information about the benefits and problems relating to different SOA options
6	Evaluate Capability Architecture	Designing and selecting SOA	Suggestion and guideline about SOA
7	Develop Business Case	Focusing and developing solution concept	The solution concept for mobile maintenance
8	Develop Solution Realization & Adoption Plan	Focusing and developing solution concept	The solution concept for mobile maintenance. Solution concept presentation

Human factors and user adoption

In addition to SE approach, some additional activities were considered necessary and useful in the process. These activities were research about acceptance and adoption of industrial mobile solutions and theoretical research about human factors relating to mobile solutions and usage. In addition to this solution piloting was also performed outside the scope of the applied approach.

The success of mobile services is not only depending on technological maturity of mobile technology and the capabilities of mobile devices. In the end, end users decide the success of the services. Herzberg's motivation and hygiene theories (Herzberg, 2003) can be exploited in the implementation and choosing of Computerized Maintenance Management Systems and Enterprise Asset Management (Bradshaw, 2000). The success or failure of CMMS depends on human factors like for example policies, rules, selection process, integration, training, support, resources, functionality, usability, usage, reviewing, work planners' motivation, work culture, skills, trust and commitment of management (Bradshaw, 2000).

User involvement can be seen as one human factor. User involvement is especially useful in the early stages of service development processes due to their high uncertainty and low formalization. Direct user-designer interaction helps in transferring user feedback and ideas to service innovations. User experience of the service is improved when users themselves can contribute to developing the service. (Kaasinen et al., 2010)

Usability can be seen as one of important factors relating to user acceptance and adoption of technology/solutions. If users perceive some solution difficult or even nearly impossible to use they will not like to use it. If users are forced to use the solution despite the usability problems they use it as little as possible and probably spend too much valuable time to get their activities accomplished.

There is large selection of different technology user acceptance models in general available. There are also some models developed to test user's acceptance, attitude and intention to adopt new mobile services and mobile technologies. Similarity in technology acceptance models' factors can be seen and in fact some of the models are based on other acceptance model in some level. The problem with using same models for industrial mobile solutions is that there are several different factors affecting on technology acceptance and adoption in industrial environment. Industrial mobile solutions must provide benefits to the business directly and/or indirectly and support employees work activities in easily usable manner.
According to the case study high level factors affecting to acceptance and adoption of industrial mobile solutions must be noticed in the process. According to the Industrial Mobile Solutions Adoption Model (IMSAM), developed in the case study, the factors affecting to acceptance and adoption of industrial mobile solutions are following:

- Mobile possibilities, needs, systems, information and integration
- Technology
    - Mobile competence and experience

- Enterprise
    - Market situation and customers
    - Regulations
    - Purposes, benefits and consequences
- Employees, users
    - Usability
    - Purposes, benefits and consequences

RESULTS

All three phases of the Solution Envisioning Approach were gone through in the case study by applying different phases' steps depending on needs and nature of the situation and project goals. Especially because of the fact that the project included several enterprises in the same domain and the Solution Envisioning Approach is designed for one at the time, some of the steps were applied loosely. One of the reasons for the customed appliance of the approach was the goals and purposes of the project. The purpose was not to design, specify or implement neither a software nor product exactly to a certain enterprise/organization as a product of the project. Instead general scientific results and information about applying mobile technology in maintenance to boost up performance were required as a result.

In the case study some phases of the approach were applied loosely or skipped depending on situation. For example it was not possible to make some specific decisions for participating enterprises. These decisions might be for example vendors, devices, roadmaps etc. In general it was possible to give information, advises, issues to be considered/noticed and research different possibilities, but not to give exact technical requirements, specifications, deadlines etc. for the product or solution.

In the case study it was discovered that the human factors are not the main focus of the Solution Envisioning Approach although the actual users are taken in to account and along for example in visioning workshops. The human and adoption factors were considered as important issue relating to success of the solutions and that's why the factors were also handled by the case study in addition to used approach. The human factors and user participation in the designing and developing process are essential when considering the success and actual exploitation of the solutions.

The approach as such is quite extensive and needs intensive acquaintance with the steps and phases. Without a practical case study it is challenging for enterprises themselves to apply the approach from scratch. By participating to the mobile maintenance case study the enterprises got valuable information and knowledge about applying the approach in practice as a process in determining possibilities and needs for different technologies and solutions in general.

The Solution Envisioning Approach was discovered as a good guideline and process in determining possibilities and needs for mobile maintenance. Now enterprises can use the approach precisely in a smaller scale to get most out of the approach. The enterprises

learned how to apply the approach in practice by themselves. The possibilities and needs for the mobile maintenance were successfully determined by following the applied process.

CONCLUSIONS

Solution Envisioning Approach was used in mobile maintenance case study as a project's process. Solution Envisioning is a problem discovery, situation assessment and solution planning process that uses Capability Cases to achieve connections between Business and IT stakeholders. Its purpose is to 'bridge the gap' between business and IT by integrating and matching concepts and techniques from both best of breed business strategy methods and software development methods. Solution Envisioning with Capability Cases is designed for use at a front end of the software development lifecycle.

In the case study Solution Envisioning Approach's all three phases were gone through by applying different phases' steps more or less exactly depending on needs and nature of the situation and project goals. Especially because of the fact that the project included several enterprises in the same domain and the Solution Envisioning Approach is designed for one at the time, some of the steps were applied loosely. Another reason for the customed appliance of the approach was the goals and purposes of the project. The purpose was not to design, specify or implement neither a software nor product exactly to a certain enterprise/organization as a product of the project. Instead general scientific results and information about applying mobile technology in maintenance to boost up performance were required as a result.

As stated before some of the approach were applied loosely or skipped depending on situation. In the case study for example it was not possible to make some specific decisions for participating enterprises. These decisions might be for example vendors, devices, roadmaps etc. In general it was possible to give information, advises, issues to be considered/noticed and research different possibilities, but not to give exact technical requirements, specifications, deadlines etc. for the product or solution.

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Overall the Solution Envisioning Approach was discovered as a good guideline and process in determining possibilities and needs for mobile maintenance. The good thing is also that now enterprises by themselves can use the approach precisely in a smaller scale to get most out of the approach. The gap between the business and technology can be now narrowed.

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E3 – Productivity

E3.1 **Analytical optimization of operational competitiveness based on sense and respond methodology**
Josu Takala

E3.2 **Identifying the lead time and pull production in built environment by value chain analysis**
Maila Herrala

E3.3 **Production optimisation: Measuring technical and cost efficiency**
Egon Žižmond

E3.4 **Productivity measurement and development in construction industry**
Aki Pekuri

ANALYTICAL OPTIMIZATION OF OPERATIONAL COMPETITIVENESS BASED ON SENSE AND RESPOND METHODOLOGY

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ABSTRACT

Global business and rapidly changing environment requires companies to determine the most critical factors of their functions. With help of them crucial processes can be further developed and rearranged. The purpose of this study is to evaluate a new Scaled Critical Factor Index (SCFI) tool developed for analytically optimizing the operational competitiveness. Study is based on previous Critical Factor Index (CFI) tool, developed by Ranta and Takala, and questionnaire form by Takala and Liu. This study especially focuses on applying Sense and Respond (S&R) method to optimize operational competitiveness of the case companies. S&R method measures future expectations, previous experiences and the direction of development. As a result of this study, a more reliable way to evaluate CFI is proposed, but it should be further studied in order to gain the correlation with the real business environment.

Keywords: Flexibility, Operational Competitiveness, Sense and Respond

INTRODUCTION

The term sense and respond (S&R) as a business concept first appeared in 1992 Management Review article by Haeckel (1992). The S&R thinking is developed by Bradley and Nolan (1998) and Markides (2000) to analyze dynamic business strategies. S&R has contribution to respond the world where it is harder to effectively make decisions and implement them under uncertain business situations in the new economy (Cunningham et al, 2002). Mahadevan et al. (2009) propose that S&R level is the highest level in service business activities and decisions. Therefore, S&R approach is required in developing strategic plans when facing unpredictable and fast changing economic environment (Kapoor et al., 2005; Schatten and Schiefer, 2007).

The identification of critical factors for businesses is crucial in order to determine the areas that need attention in order to enhance the business and/or to avoid the downfalls caused be these critical factors. Competitiveness of future manufacturing operations relies on today's actions. The determination of these factors is not necessary easy in very complex business environments. Therefore there is a need for scientific methodology that provides useful results in determining these factors.

The purpose of this research is to evaluate a new Scaled Critical Factory Index (SCFI) tool developed for analytically optimizing the operational competitiveness. The result derived from new optimizing model are compared against the results given by the Sense and Respond questionnaire method developed by Rautiainen and Takala (2003) and further developed by Ranta and Takala (2007) in order to evaluate the results of SCFI tool. The questionnaire used within these methodologies has been developed by Forss and Toshev (2010). Only the results of the experiences and future expectations from the questionnaire were used in this research to test the SCFI tool.

For more reliable results the questionnaire was sent to four different companies. The usable results concluded three companies and total of 6, 3 and 3 answers that could be used. Other answers were not complete and for one case company there was received only one answer which is not enough for reliable results.

METHODOLOGY DEVELOPMENT

Sense-and-Respond methodology

Sense-and-respond method is based to the observation that the business is done in the more unexpected environment. It is difficult to answer the customers' demands. For this reason the know-how regarding people and processes are emphasized as well the modular customization. (Haeckel 1999: 12-13.) According to Haeckel (1999: 12-13) other important factors are the processes answering to the individual demands, the modular solutions reducing costs, teams and networking establishing in an important role, share of customer spending on a class of needs and the strategy being able to make flexible changes.

On the basis of the Sense-and-Respond methodology the further developed Sense and Respond questionnaire method was developed by Rautiainen and Takala (2003) and further developed by Ranta and Takala (2007) for monitoring and evaluating the company's inner customer's experiences and expectations of forthcoming events.

Critical factor index method

CFI is method which enables finding the critical factors of the process by utilizing the experts' views. CFI diagram consists of the average of the expectation, average of the experience, standard deviation of expectation, standard deviation of experience and direction of development. It is described in following calculations.

$$Gap\ Index = \frac{Avg.of\ experience. - Avg.of\ expectation}{10} - 1$$

The source scale 1-10 has been used so the denominator is in accordance with it.

$$Importance\ index = \frac{Avg.of\ Expectation}{10}$$

$$CFI = \frac{Standard\ deviation\ of\ expectation * Standard\ deviation\ of\ experience}{Gap\ index * Direction\ of\ development\ index * Importance\ index}$$

The smaller the value of CFI the more critical the factor is. On the other hand, more than the dispersion found regarding the factor, it is it difficult to say about its criticalness. All the CFI values can be multiplied for example by 10 or 100 to facilitate the comparison in which case, however, the relationship between the factors will be kept same. CFI is often calculated according to the group, an interviewee. In addition to it, CFI is calculated by connecting the answers of all the groups to the same table by telling the groups among themselves and by counting the averages also. This way the differences between the factors are obtained more distinctly in sight. (Rajala 2009; Ranta 2007; Takala 2009.)

The Critical Factory Index (CFI) tool introduced by Ranta and Takala (2007) measures the experience and future expectations in order to find out the critical factors that are the bases for the operational competence of the business. The factors that are interpreted as critical ones are the ones that would need the most attention in company to ensure the efficiency in competitiveness towards competitors.

Research questionnaire

The questionnaire used in the research is based on the Sense and Respond questionnaire method developed by Rajala and Takala (2007). The questionnaire measures the organization's opinions about the business performance of the firm. The respondents are asked to evaluate real life experiences and expectations. Expectations and experiences for each attribute are measured in a scale of 1-10. Direction of development is compared to the situation 1-2 years earlier and the firms' level of experiences is compared to the

competitors. The respondents are asked to evaluate the direction of development and the experiences against the competitors in three scale of *worse*, *same* or *better.* The questions in the questionnaire are divided into four categories; Knowledge & Technology Management, Processes & Work flows, Organizational systems, Information systems which are further divided into sub questions resulting 21 questions. The questions that are presented to respondents are presented in Table 1 below.

Table 1: Sense and respond questionnaire questions.

ID	ATTRIBUTES
Knowledge & Technology Management	
1	Training and development of the company's personnel
2	Innovativeness and performance of research and development
3	Communication between different departments and hierarchy levels
4	Adaptation to knowledge and technology
5	Knowledge and technology diffusion
6	Design and planning of the processes and products
Processes & Work flows	
7	Short and prompt lead-times in order-fulfilment process
8	Reduction of unprofitable time in processes
9	On-time deliveries to customer
10	Control and optimization of all types of inventories
11	Adaptiveness of changes in demands and in order backlog
Organizational systems	
12	Leadership and management systems of the company
13	Quality control of products, processes and operations
14	Well defined responsibilities and tasks for each operation
15	Utilizing different types of organizing systems (projects, teams, processes...)
16	Code of conduct and security of data and information
Information systems	
17	Information systems support the business processes
18	Visibility of information in information systems
19	Availability of information in information systems
20	Quality & reliability of information in information systems
21	Usability and functionality of information systems

RESEARCH METHOD

The former S&R model proposed by Ranta and Takala (2007) has been used in many case studies already. However, the S&R model has several flaws which do not reflect real situation when only using deviations after tested in case studies. The models established by Ranta and Takala (2007) does not consider the situation of $\mathrm{Std}\{experience\} = 0$, which means that they do not consider the situation that if the given answers for each index are the same, thus the implication of different values cannot be distinguished by the models, so

does $\mathrm{Std}\{expectation\}$. If that happens, the models make no sense to analyze the real value of CFI. Therefore, this paper improves the S&R model and proposes a new CFI model (NCFI) which is shown in equation (1).

$$NCFI = \frac{\sqrt{\frac{1}{n}\cdot\sum_{i=1}^{n}(experience(i)-1)^2}\cdot\sqrt{\frac{1}{n}\cdot\sum_{i=1}^{n}(expectation(i)-10)^2}}{Gap\ index\cdot Direction\ of\ development\cdot Importance\ index} \qquad (1)$$

For each respondent i in a case company (i=1...n, n>=1, which means minimum respondent number can be 1), their experience donated by epr(i) and their expectation donated by epc(i) are integers ranging from 1(min) to 10(max). The epr(i)-1 and epc(i)-10 measure the deviation between answer and lower/upper boundary to know how critical the attribute is, resulting the absolute value of the deviation is ranging from 0 to 9, and smaller number will drop NCFI value to indicate more critical (e.g. epr is approaching lower end 1 and epc is approaching higher end 10).

The NCFI value will not reach typically 0, since the root mean square is used. The sum of all answers of (epr(i)-1) and (epc(i)-10) will be highly unlikely to be 0 even if there are little number of answers, unless all the informants answer experience=1 or expectation=10.

However, the NCFI is allowed to be 0, when all the informants have answered experience=1 or expectation=10. That means this attribute is truly an extremely critical factor. However this situation will not happen so often, and there will not be many attributes are 0 at the same time either.

Each NCFI value is then linear scaled using NCFI/sum(NCFI) so that the sum of all scaled CFI (SCFI) values will be 100%, which make it possible to compare between different case companies. Since the sum(NCFI) of every case company is different, so we are not comparing the absolute value of each SCFI between companies, but only compared with the other SCFI of the same company. By setting independent threshold value for each company it shows most critical CFI of that company, and therefore it is still possible to compare between many case companies.

RESULTS

The following comparison between the old CFI model and the proposed SCFI model is based on responses received from three different companies. From company 1 there were 6 answers received and from companies 2 and 3 there were both 3 answers received. The company 4 was left out of the study since there was only 1 answer received which could not be kept as reliable enough in term of number of. Also one partial answer was left out since it was not analyzable. The following graphs show the deviation between these two different models.

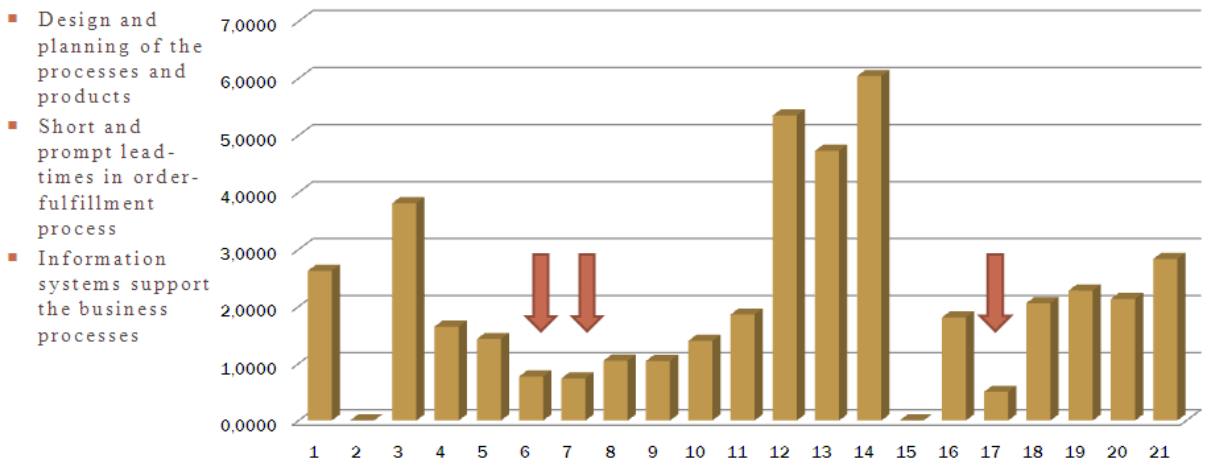

Figure 1: CFI results for company 1.

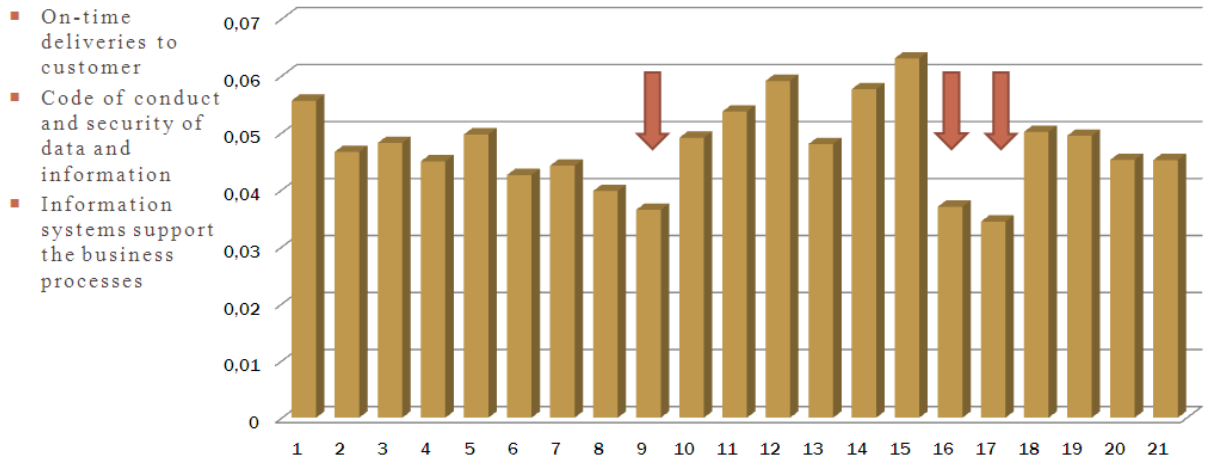

Figure 2: SCFI results for company 1.

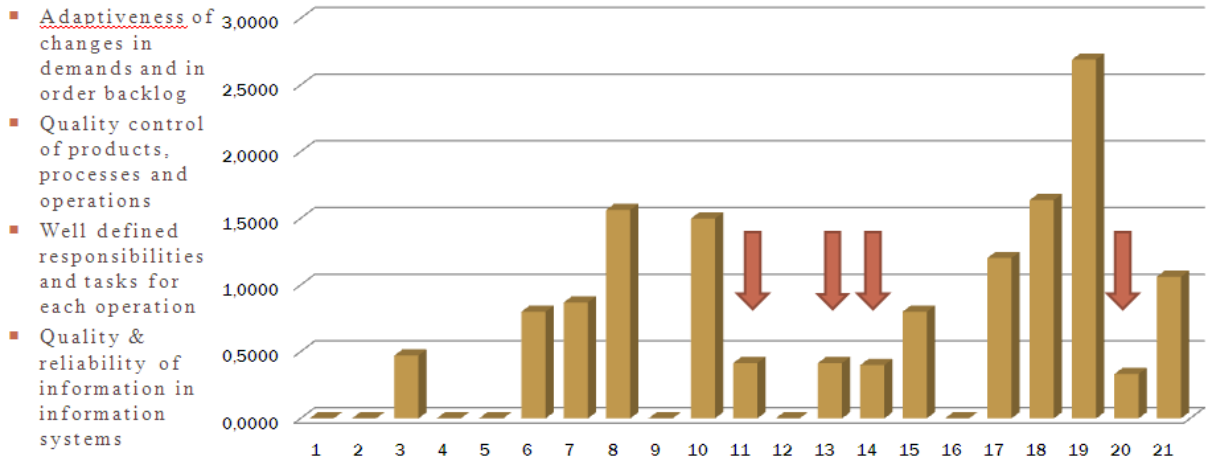

Figure 3: CFI results for company 2.

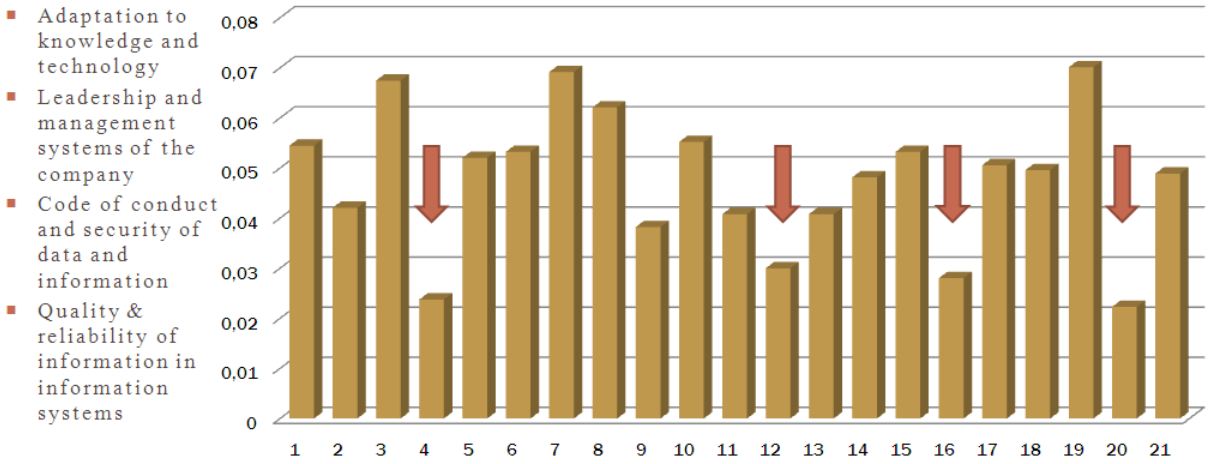

Figure 4: SCFI results for company 2.

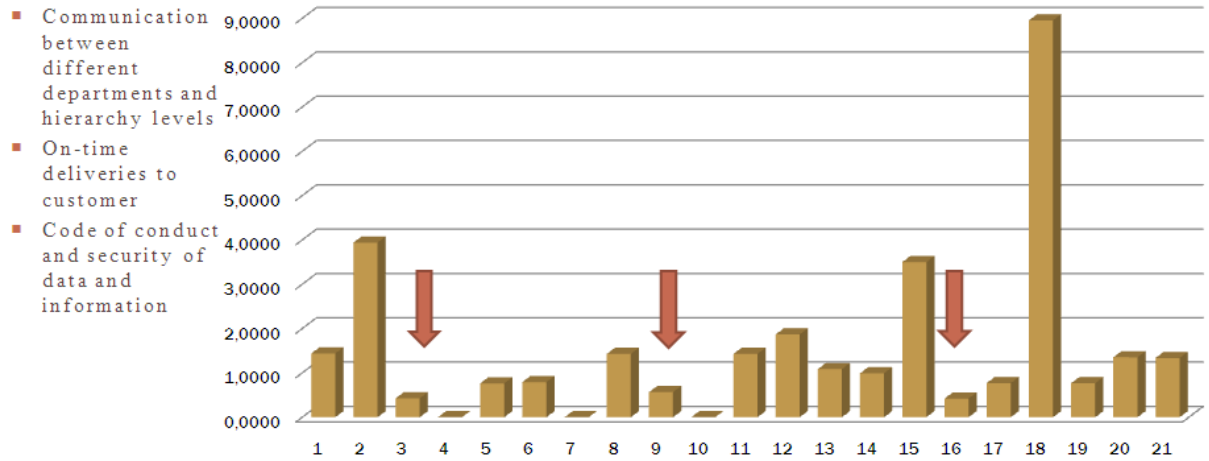

Figure 5: CFI results for company 3.

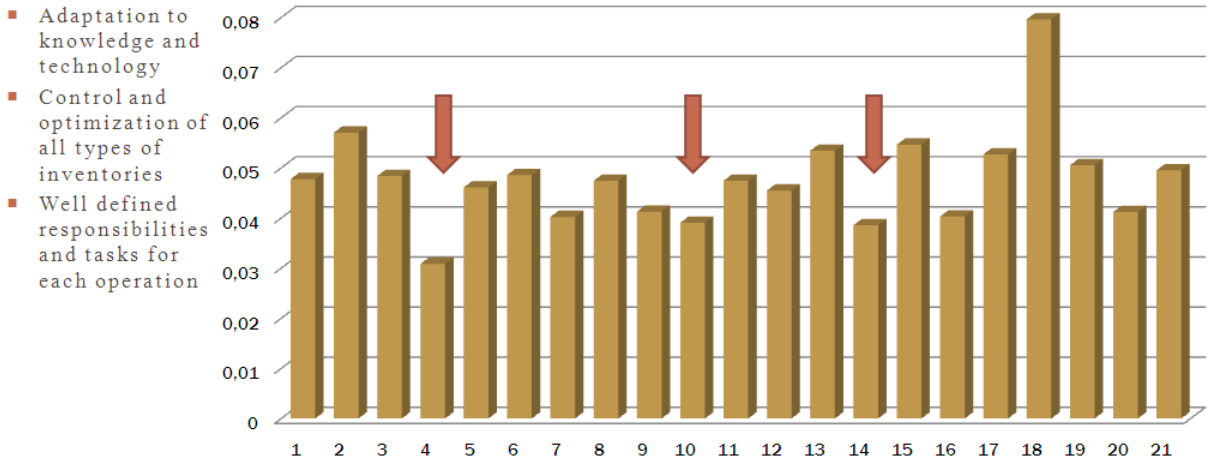

Figure 6: SCFI results for company 3.

By analyzing the results via CFI method the attributes 6, 7 and 17 in figure 1 can be identified as the most critical attributes of the company 1. On the other hand the SCFI model shows attributes 9, 16 and 17 in figure 2 to be the most critical ones. With more analysis it can be seen that the variation of the importance of the attributes varies also a lot

among the other attributes. The variation phenomenon is also clearly visible within the case companies 2 and 3. The analysis show that the most critical factors using CFI method are 11, 13, 14 and 20 in figure 3 for company 2 and 3, 9 and 16 in figure 5 for company 3, but using the SCFI method these critical factors change to 4, 12, 16 and 20 in figure 4 for company 2 and to 4, 10 and 14 in figure 6 for company 3.

Especially the problem that has been revealed with this research is that once the standard deviation of experiences or expectations go to the zero the result become less reliable. Within this study the main factor that results to this problem is the small sample size of responses that were received. Nadler and Takala (2010) were finding similar disadvantages of the CFI model on their study. Also the balanced critical factor index (BCFI) model they presented faces this same problem. This problem culminates with the company 2 as attributes 1, 2, 4, 5, 9, 12 and 16 are having a standard deviation of zero among either experiences or the expectations. With this amount of nil values it is impossible to say anything reliable about the results.

Even though there are only two attributes, 17 in company 1 and 20 in company 2, that appear to be critical in both cases it can be said that there are really critical factors to these companies. Otherwise the other factors that appear to be critical need more clarification and deeper analysis with the real business life and this research proves that no model is perfect in all circumstances as with the CFI model in this research and that the SCFI model that has been developed needs a lot more research before it can be said to be working. The feedback about the results of SCFI that was received from the company 1 was that the results are “very interesting and relevant”. So with this information the development of this SCFI model SCFI is promising and it is worthwhile to do research further to see if it is really producing relevant results in term of critical factors that can be identified to be crucial to the real business.

DISCUSSIONS

As presented above in the results the different critical factor index model result in totally different interpretations of the critical attributes. This result is uncertainty in the results which prevents us from making any supportive conclusions from the results to the analytically developed SCFI model. In the other hand SCFI model looks to be promising in terms of eliminating the standard deviation problem that is most likely to occur within small sample size researches. The standard deviation problem emerges when answers of either experiences or expectations are exactly the same among all the respondents. This means that the standard deviation becomes zero and once the CFI model is used the zero as multiplier and numerator; the critical factor index gets also a value of zero. The usage of SCFI model does not prevent the importance of single opinions in small sample size researches. This is very well know problem that the sample size should be rather bigger than smaller, but it may occur in times when there is not received enough answers from the respondents. Due to the facts these models should be evaluated in deep real business life situations in co-operation with respondents’ themselves to overcome the uncertainty of the correlation to the real life.

So hereby we propose that further researches with these models including the BCFI model introduced by Nadler and Takala (2010) should concentrate on finding the coherence between real life and the results that are derived from the questionnaires that are analyzed using these critical factor index models.

Since the other clear problem within this research is that too many attributes are getting a zero value due to the standard deviation problem the interpretation of the results becomes impossible. So in further studies this should be noted and the evaluation of this new model should be done with results that does not have the standard deviation problem to that the results itself can be compared if the critical factors are more similar that in this research. We suspect that this problem prevents us from getting even good results in terms of finding the critical factors with the CFI model. We think that the fact that was found by Nadler and Takala (2010) that the results are negatively influenced if any of the standard deviation of experiences or the expectations is below one; should be taken into the account in further research to really see the coherence between these critical factor index models.

Hereby we propose that future research should be done to really evaluate the differences between these different critical factor index models so see the differences without these influences from the standard deviation problem.

CONCLUSIONS

In order to survive within the global competition, companies must determine their critical factors. The task is challenging, since there are many variables involved. The study was based on results of three different companies, which were working in network model. There were only two attributes found to be critical, since they occurred in different calculation models. Any statements about the other attributes cannot be said, because any reliable way to calculate Critical Factor Index was not found.

All in all three different models of CFI were introduced in the paper. Weakness of the first model was standard deviation problem, which also occurred with SCFI. The main focus in further studies should be in standard deviation. Mathematic formula should be reliable in order to meet the need of the daily business. In addition sample size should be larger, in order to get reliable results that can be further analysed. Future research needs support from the companies and requires monitoring of the real critical factors. Critical Factor Index should be further studied concentrating on value- added perspective of the company. In addition function of network should be involved in the future study in order to explain why networking companies have different critical factors and how it is affected to their overall performance.

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IDENTIFYING THE LEAD TIME AND PULL PRODUCTION IN BUILT ENVIRONMENT BY VALUE CHAIN ANALYSIS

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ABSTRACT

Time is one of the key resources in the production industry and it affects observed customer value. Nevertheless, in Finnish built environment, the lead times are very long in comparison to other industries, like car industry or mobile phone manufacturing. In a built environment research project KERVO (Value chains in sustainable community), the need for more accurate lead time and production analyses was identified. First a concept to evaluate the lead time was constructed based on value chain analysis. Secondly, a case research in Finnish built environment was conducted. Based on this research, long response time and pull production is mainly caused by problems in urban planning process and stock driven production. Also, the gaps of the production flow cause additional time reserves and incoherent production. To overcome these causes it is critical to re-engineer zoning process and especially the appeal process of the zoning. In addition, value chain management is needed to enhance the value chains as a whole, so that sub-optimization of production could be diminished.

Keywords: Built environment, value chain, lean, Just-in-Time Production

INTRODUCTION

The development of the productivity in the construction industry has been low compared to other industries. In the construction industry, there has not been systematic approach to develop the production systems or technologies in order to improve productivity. The lack of development is due that contracts are divided to small portions and contractors are selected based on the price. Hence, there are fragmented and unmanaged supply chains.

Other industries, like car manufacturing, have used lean methods to enhance the production systems in the whole value chain. One of the key finding of the Toyota Production system (Ohno 1988, Shingo 1988) considers time as a resource. Their aim was to shorten manufacturing/lead time of a product. Shortened lead time enabled to reduce an amount of the work in progress and reduce stock levels. Therefore, the needed capital for production could be minimised and the return of investment enhanced. One of the lean methods to reduce lead time is Just-In-time (JIT) production. JIT production offers several

significant opportunities to lower the stock levels, reduce unnecessary working and produce products as customers asked. However, to implement JIT methods, the lead time of product must be reduced. In manufacturing industry, e.g. car manufacturing, lead time is reduced by lot size reduction, layout configuration, supplier co-operation and set time reduction. (Liker 1990, Shingo 1988, Hines et al. 2004, Shingo 1988)

In addition, shortened lead time allows better capability to react to the changes of the customers need. The enhancements were made by reducing non-value adding activities rather than focusing on the efficiency of the single process. In this way, value creation stayed the same, but fewer resources, such as time, are consumed. Hence, shortened delivery time could offer added value for customers and possibility to differentiate in the market which also makes sense from business point of view. (Walker et al. 2000, Schmenner 1988, Womack 1990, Ohno 1988).

Also in construction industry lean methods are used to enhance the efficiency of production. (Ballard and Howell 1998, Green and May 2005, Jorgensen 2006). Koskela and Vrijhoef (2000) indicates the need for supply chain management in construction so that the supply chain could be enhanced as a whole. However, the adoption has not been completely successfully, because of project-based characteristics (Riley and Clare-Brown, 2001, Höök and Stehn, 2008). Nonetheless, it is essential to gear construction to JIT -production, if lean is wanted to implement in the built environment. By JIT -production it is possible to add the residents' value with fewer resources. Thus, JIT offer a possibility to enhance the productivity of the whole industry (Koskela 2000). In addition it could have significant impact on the profitability of the whole industry (Crowley 1998).

To enhance production and gear it towards lean, value stream mapping (VSM) is commonly used to analyse order-delivery process. By VSM, the production can be re-engineered so that lead time can be reduced in the whole value chain. Value stream mapping is a tool developed by Rother and Shook (1996), but its origins are as far as Ohno's Toyota production system (Ohno 1988). At that time, it was called a material and information flow mapping, which describes the main flows analysed. After that the VSM and its tools have been developed in several studies (eg. Hines and Rich 1997, Hines et al 2004, Lasa et al 2008, Womack and Jones 2009). Value stream mapping and its tools are geared to analyse the whole order-delivery process that non-value adding activities can be pointed out. These tools are not focused on value adding stages but they indicate where the waste is produced during the order fulfilment. Especially time is an important meter of the value stream mapping tool because it indicates how big portions the non-value adding activities take of the production lead-time. In several studies it has been pointed out that only small percentage of the lead-time is value adding, commonly below 10% (Chen and Meng 2010, Woll 2003, Womack and Jones 1996). There are some value chain analyses made in the construction industry (Segerstedt and Olofsson 2010, Gustavsson and Marzec 2007), however, in Finland these kinds of analyses have not taken place yet.

Based on the good results of the lead time reductions in the other industries, the hypothesis for this research is set as follows: *How to enhance the lead time of the built environment?* This question frames the basic of this research and the research questions are derived from this question.

RQ 1: How the value stream mapping tool has to be modified for the analysis of the built environment?
RQ 2: What are the problem areas identified in the Finnish built environment?
RQ 3: What is causing the problems of the supply?
RQ 4: How these causes could be eliminated based on lean philosophy?

The first aim of this research is to find an appropriate framework to evaluate the production of the built environment that further analyses could be executed. Although the VSM has been used several industries, it had to be modified for this research environment. Main reasons for modification were the long horizontal value chains and specific need to analyse the lead time of the value chains. Therefore, the selection process of the value stream mapping tools was executed and appropriate analysis model constructed. Secondly the analyses of selected built environment value chains were executed. Objective is to analyse the lead time and its generation in the built environment. An analysing framework is used to show the lead time generation in a case built environment. The third research question focuses on identifying causes for problems in the current process. Objective of the fourth research question is to find solutions to shorten lead time based on lean manufacturing. The progress of the paper is presented in figure 1.

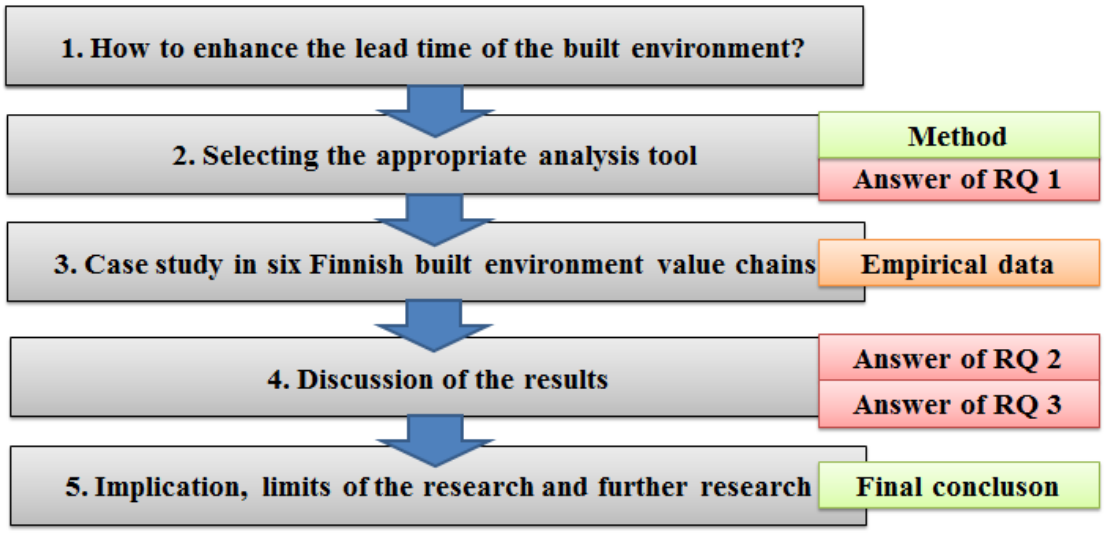

Figure 1: Progress of this paper.

By analysing the value chains of the Finnish built environment, it is possible to indicate the problems of the Finnish construction system and enhance it. VSM offer an opportunity to analyse the value chains as a whole so that the lead time of Finnish built environment production system could be reduced. VSM indicates three main flows of the value chains. Information flow indicates how the production is controlled, material flow indicates the production flow and time line indicates the flow of the value adding activities. Hence, VSM constitutes a comprehensive model of the production system.

RESEARCH METHOD

To analyse the lead time and production type of built environment, a review of production philosophies was conducted, so that appropriate model could be selected as a basis of the research. After review, the lean philosophy was selected because lean methods have been

indicated suitable for construction (Koskela 2000). Also the characteristics of Finnish built environment were researched from literature. As a result of the reviews, value stream mapping was selected as a tool for analysing the built environment. Value stream mapping was selected because it separates the value adding operations from waste (Womack and Jones 2009, Womack and Jones 1999, Womack and Jones 1996). By value stream mapping, it is possible to form a comprehensive understanding of the order-delivery system, because all activities (both value adding and non-value adding), information streams and time are mapped (Hines et al. 1998). The usefulness of the value stream mapping is presented in several researches (Kaplinsky 2000, Woll 2003, Taylor 2008). After the appropriate framework was created, a case study in one Finnish built environment was conducted. In the case study six different value chains were analysed. Information for case study was collected by interviewing 25 specialists from 15 organisations. Interviews were recorded and answers were typed into data sheets. In addition, value chain was modelled with the interviewees so that gathered data could be verified. Raw data was analysed by authors who also redraw merged value chains. Based on the material, the problem areas, root causes for problems and development targets were identified.

Short description of the case study

The case study included six different types of value streams. These are the main value chain types of the Finnish built environment and therefore give a representative sample. The analysed value chains were as follows:

- Infrastructure value chains
    1. Street networks (Municipality owned)
    2. Water networks (Municipality owned)
    3. Energy networks (Municipality owned)
- Real estate value chain
    1. Condominium housing (Privately owned)
    2. School buildings (Municipality owned)
    3. Commercial real estate (Privately owned)

The case study has a comprehensive horizontal scope of the value chains. All value chains are mapped from zoning stage to disposal of the structure. The analysed value chains were modelled by process activity mapping and included on average 80 activities each. Because of the large size of these maps, they were not included in this paper. However, in Figure 2 the main stages of the value chain are presented. The level of analysis was kept on the industry level rather than at the company level. Value chains were modelled by using the swim-line process chart, which is one of the applications of the flow charts (Krajewski et al. 2002). By using the swim line modelling, the role of the organisations in the value chain could be emphasised.

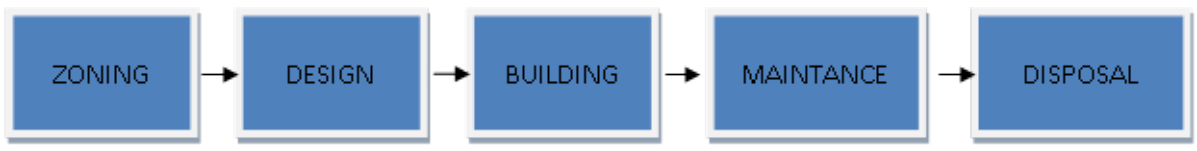

Figure 2: Main stages of researched value chains.

Analysing model

Based on the literature review of lean and VSM, an analysis framework was created. First, a collection of VSM's tools was gathered. Secondly, the appropriate tools were selected by assessing the benefits of the tools. The assessment was carried out by the researchers, who weighted the correlation between the research focus and tool benefits. After that the tools were selected for five target areas (Table 1).

Analysing framework target areas and tools.

Target area	Tool
Identification of value	Customer need
Value chain	Process activity mapping
Flow	Gap analysis
Pull production	Decision point analysis
Response time	Supply chain response matrix

First target area is the capability of value chain to identify customer value. This area is researched by analysing the customer need identification process. There are two main questions related to this area: How do the organisations identify their customers? How do the organisations find out their customers' need?

Value chain is mapped by process activity mapping. In this research, we wanted to separate organisations but still form the continuous picture of the activities. In this manner, we could analyse the roles of the organisations in the value chain. The flows of the whole value chain were analysed with GAP-analysis tool, which helps to analyse the problems of the flow.
The type of the value chain was analysed by decision point analysis. With this tool, we wanted to indicate which activities are demand/push driven and which are forecast/pull driven. The fifth area is the response time analysis, which indicates all the time needed from raw materials to shipment. This is not the same as an order lead time, but production lead time indicates the capabilities of the production system. Production lead time analysis indicated where the most time is spent during the product supply. Thus, it indicates the most attractive development areas.

RESULTS

After the data was gathered by interviewing the representatives of the value chains, data was analysed. Based on the analysis, three main finding can be presented. The first finding is the formation of the production lead time. Second observation considers the flow in the value chain. Third main result of this research is the indication of the production type. These three areas are presented next.

Production Lead Time

As a result of analysing six value chains, lead time of the case is presented in Figure 3. In the picture, the time spent in the production is on the horizontal axis and the time spent in the stock is in the vertical axis. This tool does not present actual amount of the lead time but indicates the relative difference between of the activities. This is due that there is a lot of variance between different projects but relative amounts are comparable. Anyhow, the

major development areas can be pointed out, because there is significant difference between activities.

As can be seen from the Figure 3, the zoning phase constitutes a very significant portion of the lead time in the Finnish built environment. The reason for long waiting times during zoning phases is slow decision-making and long appeal times. Every individual who is linked in the zoning area can make an appeal, which is wrought in the court. Although not all town plans are taken to the court, the appeals are usual and even unnecessary. Some people try to slow down the process and even extort by making the appeal. In addition, during the zoning process the zoning papers are approved several times in the municipal council. There are two main stages; general zoning and detailed zoning. Problem is that these two processes work quite separately so that there are matching problems between these processes.

By developing these key points, zoning could be more fluent and the lead time of the whole value chain enhanced significantly. It would also offer better value for the customers because they could access the final infrastructure faster.

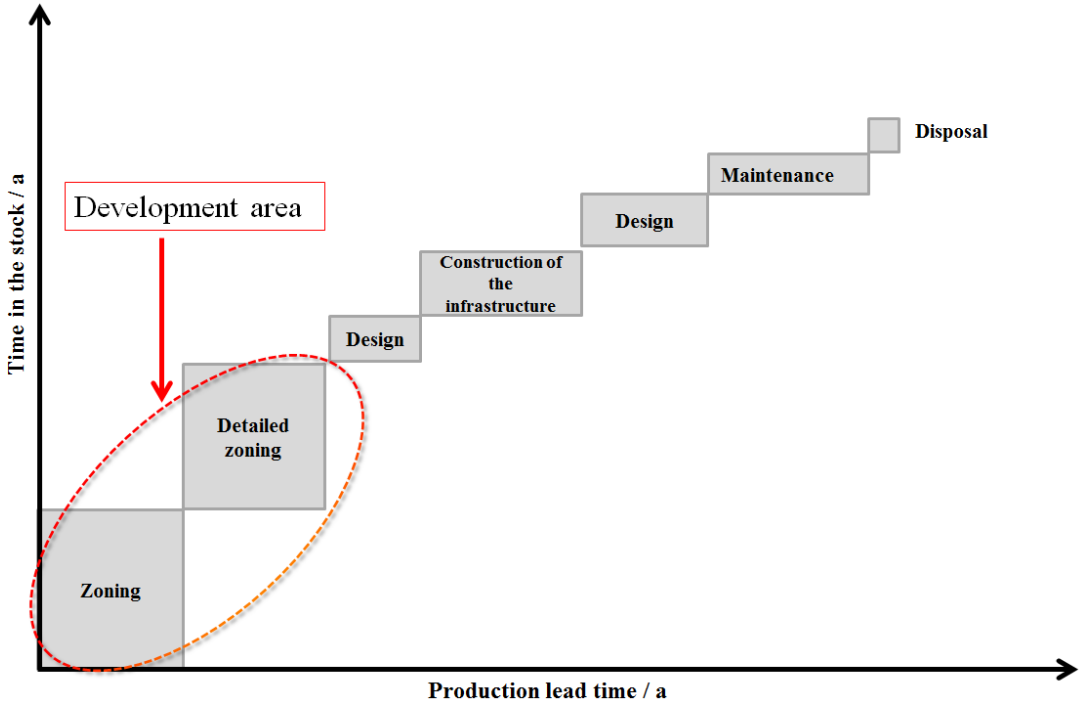

Figure 3: Production lead time.

Flow of value chain

Next step of analysis pointed out the gaps of the flow in the value chain so that reasons for long lead time could be analysed. We were especially interested in the information flows in the value chain. In Finnish built environment, the production is divided into small portions, because the actual operations are executed by small and specialised companies. Therefore, there are long and fragmented supply chains. Furthermore, the links between the contractors are weak although they are working in the same project.

A specialised tool, the GAP –analysis, was used to demonstrate these gaps in the flow. In this manner, the main reasons for the inconsistency of the value creation could be understood. Based on the analysis, five main gaps are found as illustrated in Figure 4. First gap is inside of the municipal zoning. The information flow between the general zoning and

detailed zoning is lacking which causes changes and inconsistency in the planning process. Consequently, there are different visions about the area development.

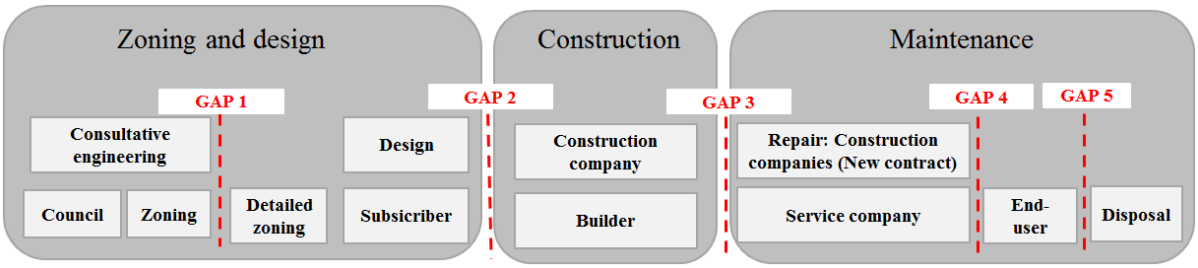

Figure 4: Gaps in the flow of the value chain.

Second gap is between the design and the construction phases. The problem is that there are very little or not any links between design and installation phases. Usually design companies and the construction companies are different and are competed separately. Design phases are focused on technical solutions and do not pay attention for assembly. Therefore the planning of the assembly is not really recognised at the design phase. Respectively, the problem is that the constructor order materials, which affect the design of the structure.

The third gap is between construction and maintenance phases. The life-cycle of the structure is not usually considered before the maintenance phase, because maintenance is considered as a separated part. This is due that the zoning, design and construction companies do not have the responsibility of the life-cycle of the structure. In addition, the revenue logic of the companies is not based on the quality of the product but on the amount of space. The lack of the responsibility of the structure life cycle may lead to bad quality of the built environment.

Fourth gap can be found between users and maintenance. The main reason for this gap is the lack of knowledge of maintenance. Thus, some of maintenance work is done too late that causes additional costs. Also, the knowledge of construction is missed, because the repairs are not linked in the maintenance or construction phases of the structure. If the maintenance is done properly and in time, it would offer additional value for end-users. Especially, it would be important to consistently pay attention to the life-cycle in the early phases of the value chain, like in the design and construction phases.

The fifth gap is between maintenance and disposal. This gap is presented because the disposal is unrecognised part of the value chain. No one in the value chain considers this part important, because it is so far in future. However, from an environmental point of view this is very important, because all materials have to be disposed somehow. In addition disposal phase forms also costs. Hence, it would make sense to find out re-use departments and consider the recycling of the materials.

Production type

On the final stage, the analysis of the production type of value chain was executed. This analysis indicates to what extent customers' needs lead the production. Production type

analysis is important, because it points how quickly the value chain can react to changes in variance of the customer's need. In addition, gearing value chain towards push production helps to reduce the stock levels.

In the Finnish built environment, a lot of the production is executed without the specific customer need as illustrated in Figure 5. Based on the research data, this is even more problematic in the real estate value chains than in the infrastructure value chains. In the real estate value chains, the old construction style where builder starts the project without customers, causes that houses are produced to stock. In the infrastructure value chains, the customer need rolls a little bit further, because these all are public administration organisations. However, there are still barriers between different actors.

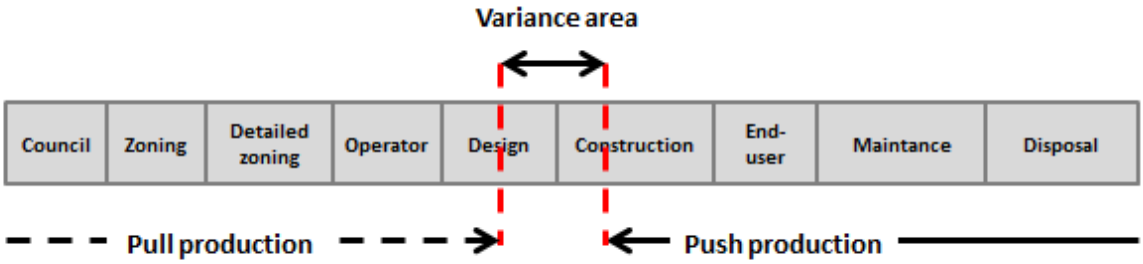

Figure 5: The production type of the value chain.

As Figure 5 shows, pull production dominate until construction. All the planning phases are done based on forecasts not direct customer need. This is a very significant problem, because in these phases the key factors of value creation are decided. In addition, it means that these phases cannot easily react to the changes of the customer need.

DISCUSSION

The main observation made in this study, is the long lead time of urban planning and the major stocks at the beginning of the value chain. These inventories consist of the work-in-process during urban planning and of unauthorised urban designs waiting for adoption (work done to stock). These stocks are owned by municipalities. Appeal time could be mostly eliminated if the quality of zoning processes is proved by quality criteria. Based on the quality criteria, it would be easy to point out that the process is executed as stated and the unnecessary appeals could be prevented. In addition, the self-explanatory processes in the zoning stage could reduce the appeals, because the citizens could notice that process is executed as required. In addition, the lead time could be reduced by enhancing the communication between organisations. This can be done by integrating the value chain organisations at the beginning of the project and by planning the assembly.

One more reason for long response time is lack of production control which causes a lot of variance in the production. Therefore, the organisations of the value chains have to take additional reservations when making a timetable. Based on project management studies (e.g. PMBOK 2004), allocated time is always used although the additional time would not be necessary. When every organisation takes these additional reservations, the lead time is

significantly longer than needed. The variance causes a lot of additional work, like rearrangements, because works are not finished in time. Variance could be managed by controlling the tasks and measuring used time. One good way to enhance the reliability is last planner system, where the organisations of the value chains are integrated to do the assembly timetable together. Therefore, the planning of the assembly could provide significant lead time reductions by eliminating the variance of the assembly. (Gabriel 1997)

The gaps in the flow cause incoherent value creation process, because value chains are geared towards local optimums rather than global optimum. The gaps are formed because the organisations of the value chain do not recognise each other's needs but organisations focuses on producing their own sub-products. This is due that no one have the responsibility and view of the whole value generation process. Hence, there should be clear responsibilities of the management in the value chain and all organisations revenue logic should be linked to overall value production. To implement the change, there is a need for new contract models, where organisations share common goal and responsibility of the project. In addition, information sharing between organisations is weak, because there are barriers between organisations. These barriers consist of the prejudices and old habits of doing things. Therefore, there are not discussion and common understanding how these organisations could enhance value generation and especially enhance their business. To improve the information sharing, organisations should build up clear channels and habits for information sharing.

Due to long response time, value chain is mostly geared towards push production. Only a few steps (mainly maintenance and service) are pull driven. Thus, almost the whole value chain production is forecast driven and customer needs are badly recognised. In addition, pull production causes unresponsive production and pull bullwhip effects in the value chains. These problems occur when there are changes in customer needs. These effects make the whole construction industry very unstable and riskier than it should be. These risks are added to the price of the construction. To gear the order-delivery system towards pull production, it is essential to shorten lead time, scale down production patch sizes and enhance the understanding about the customer demand. In addition, the basic meters like work in progress and size of the stocks could offer insightful information because currently these stocks are seen as a good reserve although they are waste.

Based on the analysis, a table of problem areas and theirs causes is formed (Table 1). In addition, based on literature and interviewee recommendations some ways to enhance the problem are presented. These recommendations are not the only ones but indicate that these problems and their causes could be solved.

The problem areas, causes for problem areas and methods to enhance

Problem	Cause	What to enhance?
The long response time in zoning process	The long appeal period.	Standardized process based on Quality Management. Sample testing. (Deming 1981)
	Large baths sizes	Using modularity system at early stage of the process. Planning as a basic level.(Lennartsson 2008)
	Communication problems. Especially considering production needs	Integrated project teams early in the project. Operations planning and control. (Isaac and Navon 2010)
	Unreliable project delivery, variance	Last planner, understanding time as a resource. Subcontractor control (Perera et al. 2010). Lean project management (Gabriel 1997, Rybkowski 2010)
Gaps of the flow	Incoherence of production	Organisations linked to the overall success of the project. => New contract models. (Ross 2009)
	Gaps between supply chain activites	Supply chain management (Koskela and Vrijhoerf 2000, Saad et al 2002)
	Problems of the information sharing.	Clear channels for information sharing. Adapting new ways to do construct, like project companies.(Salvatierra-Garrido 2010)
Push production	Long response time	Shorten response time (Look previous section)
	Focus on standards, not on customer need	Focusing on customer needs and identifying process. Understanding the possibility to differentiate on markets. (Walter et al 2001)
	Storages are not understood as a waste	Calculating the capital invested and return of capital.
	Large bath sizes	Focusing on steady production. (Womack and Jones 1996, Koskela 2000)
	Forecast driven production	Kanban methods for construction (Ohno 1988, Arbulu 2004)

Problems of the value chains are caused mainly by bad information sharing, large bath sizes, unreliable production and big stocks. Information sharing between organisations is not at the required level, because there are not clear channels to share information and only technical data is shared. Large bath sizes cause pulses in the value chain that causes bullwhip effect in the value chain. Unreliable production causes unnecessary time reservations and additional work. Big stock at the beginning of the value chain, at the zoning phases, causes the biggest portion of the lead time.

All presented causes for problems in the Finnish built environment are quite similar with the manufacturing industry. Therefore it was interesting to look for lean solutions for these causes. To shorten lead time it would be interesting to exploit the quality management tools, like sample testing. By this manner the approval process could be accelerated. Also, normal lean methods like standardisation, better information sharing, smaller bath sizes and lower stock rates could reduce the lead time and gear production towards JIT production. In addition, lean construction methods like the last planner system and integrated project teams, would offer significant benefits because these methods would merge organisations

of the value chain and enforce to do assembly planning. This all means closer relationships of the value chain organisations that enhancement could be continuous.

CONCLUSIONS

In this research the lead time and the production type of the Finnish built environment is analysed. Lead time analysis is interesting because time can be seen as a resource of the order-delivery process (Womack 1990, Ohno 1988). Therefore, by reducing the lead time of the supply, the efficiency of production can be enhanced as Toyota model has shown. In addition, by reducing the lead time, better value can be offered for customers by reacting faster and by producing more customised products. There is evidence of that in other researches (e.g. Walker et al. 2000)

Previously, order-delivery process analyses of this kind have been done in the manufacturing industry with good results. These analyses are done with the value stream mapping tool, which is geared towards lean philosophy. However, similar value chain analyses have not been done in the Finnish built environment. Hence, it seemed interesting to analyse the capability of the value creation process in the context of the Finnish built environment.
Based on the literature review of the value chain mapping researches, the appropriate tool set was selected for the analysis of Finnish built environment. Modification was needed, because the scope of the study was wide and included several organisations. As a result of the selection five tools were selected: Customer need, Process activity mapping, Gap analysis, Decision point analysis and Supply chain response matrix. These tools formed the analysis framework, which were then used to analyse the case value chains.

Six Finnish built environment value chains were analysed as a case study. In these value chains, the main factors causing long lead time were long response time in the zoning stage, gaps between the flow and the push production. In the zoning stage a lot of time is consumed waiting for approval and during the appeal process. The gaps cause incoherent production, which is not managed as one system. Hence, there are a lot of local optimums but no common goal, which causes a need for buffers like stocks.

The results of the study offer significant possibilities to enhance efficiency and the value generation of Finnish built environment. The efficiency is generated because fewer resources are needed during the project. For example, fewer resources are engaged in work in progress and stocks. Additional value is generated for the customers, because of the faster delivery. From a business point of view, suggested enhancement could offer fewer risks, because the variance of the project delivery could be reduced. In addition, there would be possibilities to generate new business models by linking value generation and revenue logic. Hence, there would be possibilities to differentiate on the markets and enhance the profitability of the industry.

There are several limitations in this study. First consideration links to the research scope and used tools. The analysis was done based only one tool, value stream mapping. In addition, the tool had to be modified for this study. Therefore, the analysis framework was totally new and it has never before tested. Hence, there is no previous evidence that VSM would

be an appropriate tool for this kind of analysis. Also, the researched value chains were wide so that organisation-based analysis could not be executed. Hence, the results are based on average approaches rather than real projects. The research method was case study and these results are limited for these six value chains of the studied built environment. Some of the results can be generalised for Finnish built environment, but for other nations these results can hardly be applied because of the difference in the standards and laws.
For further study, it would be interesting to do the same kind of research in other Finnish built environments so that the results of this study could be validated and generalised. Also, new studies would offer insightful information about how value chain mapping applies in these kinds of studies. In addition, the testing of the recommended lean methods, like last planner, in the real projects could offer evidence whatever these tools are appropriate tools for solving presented problems.

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PRODUCTION OPTIMISATION: MEASURING TECHNICAL AND COST EFFICIENCY

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ABSTRACT

*The goal of Real Time Production Optimization (RTPO) models is to improve the efficiency and predictability of the optimization methodology itself, and to improve the flexibility in terms of the types of proxy models that can be used. Considering the present state of the art among the production optimization frameworks, the **Overall Equipment Efficiency (OEE)** methodology is the most popular one. However, this and other (RTPO) methodologies approach production optimization only from the technology point of view and ignore the economic perspective of optimization.*

*This is why we developed a new key performance indicator **Overall Cost Efficiency (OCE)** aimed at measuring the cost efficiency of a production process in real time. Its application is based on the Overall Equipment Efficiency (OEE) measurements and is convenient for application in industrial management praxis. We have used an ordinary mathematical modelling approach combined with descriptive microeconomic analysis techniques. The OCE algorithm is an original advanced improvement of a popular OEE framework.*

Keywords: Technical efficiency, Overall equipment efficiency (OEE), Cost efficiency, Overall cost efficiency (OCE), Industrial management.

INTRODUCTION

Production optimization is one of the important research fields that lies at the cross-section of a microeconomics, mathematics and informatics. One of the special research issues includes the so-called Real Time Production Optimization models (RTPO models). Their goal is to improve the efficiency and predictability of the optimization methodology itself, and to improve the flexibility in terms of the types of proxy models that can be used. The natural background for development of the production optimization models is provided by the mathematical optimization techniques (see for instance Strasek 2003 for their overview).

Considering the present state of the art among the production optimization frameworks, the Overall Equipment Efficiency (OEE) methodology is the most popular one. However, this and other (RTPO) methodologies approach production optimization only from the technology point of view and ignore the economic perspective of the optimization.

The present paper introduces a new key performance indicator (KPI) aimed at bridging this gap. Our KPI measures not only the technical efficiency of production, but also the belonging cost efficiency in real time. Especially from the industrial management and from

the productivity management point of view, it is crucial to know by what percentage the actual costs are higher due to the reduction of technical efficiency. For this purpose we suggest the use of our Overall Cost Efficiency (OCE) framework. Its theoretical deduction is the basic issue of the article.

The content of the article is organized as follows. In chapter two the Overall Equipment Efficiency (OEE) framework is reviewed. In chapter three the microeconomic relationships between productivity and production costs are described. Chapter four develops an Overall Cost Efficiency (OCE) framework. Chapter five develops an industrial management point of view on the OCE. Chapter six concludes with the pilot case study of OCE.

TECHNICAL EFFICIENCY AND OVERALL EQUIPMENT EFFICIENCY (OEE) FRAMEWORK

In manufacturing practice, especially in the case of automated production lines for mass production, the use of a key performance indicator (KPI) termed as Overall Equipment Efficiency (OEE) is very popular – see for instance Sharma et al. (2006, 261–264), Dal et al. (2000, 1488–1502). The OEE was introduced by Nakajima (1998), aimed at supporting the processes of total productivity maintenance (TPM). From the methodological point of view the OEE is a productivity metric that estimates the technical efficiency of a production process by controlling the availability, performance and quality of the production process – see for instance Huang et al. (2003, 513–527), De Ron and Rooda (2006, 4987–5003), Jonsson and Lesshammar (1999, 55–78) for scientific evaluation of the OEE and for the relevant analysis on the present state of the art.

There exist different varieties of the mathematical specification of an *OEE*, where the common framework is given as:

$$OEE = A \cdot P \cdot Q. \tag{1}$$

Symbols: OEE – overall equipment efficiency,
A – availability rate,
P – performance rate,
Q – quality rate.

The first parameter is the availability rate (*A*) which measures the share of effective operating time in total operating time. The total operating time (*TOT*) is a time-span within which the production process can proceed. However, due to different reasons, the production process does not take place within the whole available time-span. Therefore, a time-span within the production process in drive is measured as an effective operating time (*EOT*). Hence, the availability rate is a relative coefficient calculated as:

$$A = \frac{EOT}{TOT}. \tag{2}$$

Symbols: A – availability rate ($0 \le A \le 1$),
EOT – effective operating time,
TOT – total operating time.

If a production is a smooth process without any breakdowns and stops, then the effective operating time (*EOT*) has to be in line with the total operating time (*TOT*), and the coefficient of availability (A) reaches its potential level 1. If the effective operating time diminishes, the availability rate diminishes towards its minimum level 0.

The second parameter is the performance rate (*P*), which is a relative coefficient with an actual production speed (*APS*) in the numerator and a potential production speed (*PPS*) in the denominator. The production speed measures the amount of production in a certain time unit (for instance 1000 pieces per hour). According to this, the performance rate is calculated as:

$$P = \frac{APS}{PPS}. \tag{3}$$

Symbols: P – performance rate ($0 \le P \le 1$),
APS – actual production speed,
PPS – potential production speed.

In the case of full efficient production, there is no deviation between the actual and the potential production speed. However, due to various inefficiencies, there occurs the problem of speed reduction of the production process. Consequently, the actual production speed is reduced below its potential level, and the performance rate diminishes towards its minimum level 0.

Finally, there is the quality rate (*Q*). This parameter measures the share of good pieces of production in the total production realized within the effective operating time and at the given performance of the production line. According to this, the following definition equation is used when estimating the quality rate:

$$Q = \frac{TP}{TP_{\max}}. \tag{4}$$

Symbols: *Q* – quality rate ($0 \le Q \le 1$)
TP – actual total product (amount of good products),
$TP_{\max}$ – maximum total product (potential amount of products).

In the case of full quality production, there is no deviation between the amount of good products and the potential amount of products. However, due to various inefficiencies, the amount of good products is reduced below its potential level, and the quality rate diminishes towards its minimum level 0.

There exists an extensive amount of theoretical and empirical literature on the explanation and prediction power of *OEE* and its practicability for productivity management (see for instance Cebrain and Vinegla, 2002; Chou and Hsu, 2005; Leem and Kim. 2004; and Wang et al. 2004). However, so far one important point has not been recognized enough. Namely, everything that has an influence on production has also a systematic impact on production costs. In the following section this relationship is described.

RELATIONSHIPS: PRODUCTIVITY – AVERAGE COSTS AND TECHNICAL EFFICIENCY – COST EFFICIENCY

Production is a technical process with a relationship between the amount of used production factors (such as energy or raw materials, working hours etc.) and the total product. Analytically these relationships are presented by the so-called technical coefficients:

$$a_i = \frac{X_i}{TP}. \tag{5}$$

Symbols: a_i – i-th technical coefficient,
X_i – amount of i-th production factor used,
TP – total product.
Note: In this case we do not distinguish between actual and potential total product.

This technical coefficient measures the amount of i-th production factor used for producing a unit of final product.

The inverse value of the technical coefficient is the average productivity of the selected production factor:

$$AP_X = \frac{TP}{X_i}. \tag{6}$$

Symbols: AP_X – average productivity of production factor X,
X_i – amount of i-th production factor used,
TP – total product.
Note: In this case we do not distinguish between actual and potential total product.

The above specified average productivity measures the amount of total product per unit of i-th production factor X.

If we multiply the amount of the i-th production factor used by the belonging price of the production factor we obtain the costs of the i-th production factor. When adding up these partial costs, we obtain the total costs:

$$TC = \sum_{i=1}^{n} \left(X_i \cdot p_i \right). \tag{7}$$

Symbols: TC – total costs,
X_i – amount of i-th production factor used,
p_i – price of i-th production factor.

Finally, if we divide total costs by the amount of production, we obtain the so-called average costs that measure the amount of total costs per unit of product:

$$AC = \frac{TC}{TP}. \tag{8}$$

Symbols: AC – average costs,
TC – total costs,
TP – total product.
Note: In this case we do not distinguish between actual and potential total product.

If we relate average productivity (6) with average costs (8), keeping the price of production factor used constant, we can deduce the relationship between average productivity and average costs as follows: "*An increase of the AP_x demonstrates growth of TP by keeping the amount of production factor used unchanged. Consequently, the numerator in equation (8) is unchanged and the denominator is higher, thus causing a decrease of the AC, and vice versa.*" This demonstrates the inverse relationship between average productivity and average costs.

However, the focus of our analysis is not on average productivity and average costs, but on the relationship between technical efficiency and cost efficiency. For this purpose we have to introduce optimality criteria:

- In the case of average productivity, the optimality criterion is the highest possible amount of production per i-th production factor used.
- In the case of average costs this criterion is the lowest possible costs per unit of product.

Hence, we have to distinguish between potential and actual productivity and between potential and actual average costs. Graphically this issue is presented in the Figure 1.

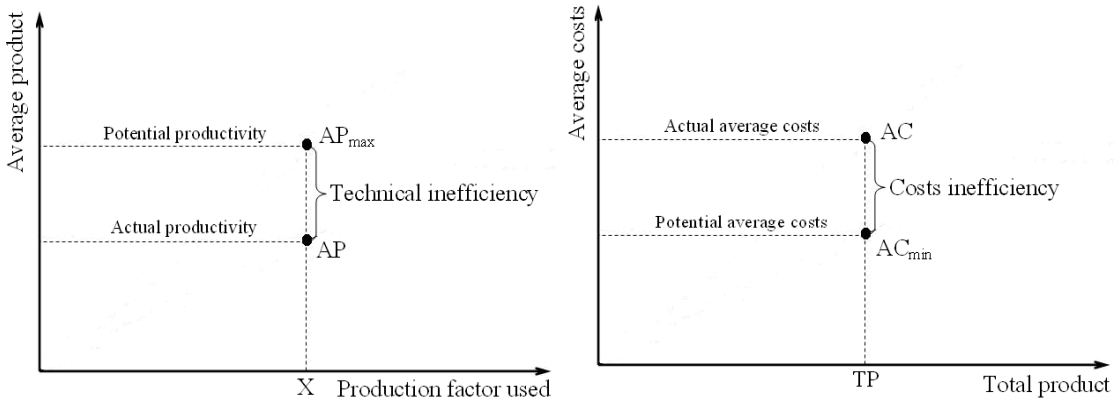

Figure 1: Technical and cost inefficiency.

On the left side of Figure 1 the graphical deduction of technical inefficiency is presented. The amount of production factor used equals X and is related with the average productivity at the *AP* level. However, the actual productivity level is below the potential productivity (AP_{max}). The potential productivity level is reached in specific cases when full availability $(A=1)$, maximal performance $(P=1)$ and full quality $(Q=1)$ are jointly reached. There are numerous inefficiency factors which reduce the availability and/or performance and/or quality, and cause the decrease of actual productivity below the potential productivity. The distance between actual and potential productivity is termed as technical inefficiency.

At this point it is important to highlight two different terms with equal meaning: technical inefficiency and technical efficiency, where both measure the difference between actual and potential productivity. In our case we recommend using the term technical efficiency rate, which does not measure the difference between actual and potential productivity, but rather the ratio between actual and potential productivity as follows:

$$TER = \frac{AP}{AP_{\max}}. \tag{9}$$

Symbols: *TER* – technical efficiency rate, 0 ≤ TER ≤ 1,
AP – actual average productivity,
AP_{max} – potential (maximum) average productivity.

If *AP* equals AP_{max} then *TER* equals 1, implying full technical efficiency – actual amount of production equals the potential amount of production.

On the right side of Figure 1 the graphical deduction of cost inefficiency is presented. The obtained cost inefficiency is the consequence of technical inefficiency. Namely, in the case of the production process analyzed in Figure 1 the amount of production factor used equals X. If this amount of production factor used is related to the potential productivity, then the lowest possible average costs are reached. When actual productivity is below the potential one, average costs are above the potential level. The distance between actual and potential average costs is termed as cost inefficiency.

In this case it is important to highlight two different terms with equal meaning: costs inefficiency and costs efficiency, where both measure the difference between actual and potential average costs. In our case we recommend using the term costs inefficiency rate, which does not measure the difference between actual and potential average costs, but rather the ratio between actual and potential average costs as follows:

$$CIR = \frac{AC}{AC_{\min}}. \tag{10}$$

Symbols: *CIR* – cost inefficiency rate, $1 \leq CIR \leq \infty$,
AC – actual average costs,
AC_{min} – potential (minimum) average costs.

If *AC* equals AC_{min}, then *CIR* equals 1, implying zero cost inefficiency (or full costs efficiency) that can be achieved only in the case of full technical efficiency. If technical efficiency diminishes towards zero, costs inefficiency rises towards ∞. Namely, technical efficiency at value zero implies TP = 0. As we know from (8), actual average costs are calculated as the ratio between total costs (in numerator) and total product (in denominator). When total product equals 0, the value of actual average costs expands towards∞. Hence, the value zero of technical efficiency (i.e. full technical inefficiency) is related with infinite cost inefficiency.

Now, since the definition equations for technical efficiency rate (*TER*) and cost inefficiency rate (*CIR*) have been established, their co-domains can be deduced.

- The co-domain of the technical efficiency rate (*TER*) is the interval [0, 1]. Rate 0 is reached if the actual amount of production equals 0, and level 1 is reached if the actual amount of production equals the potential amount of production (i.e. actual productivity equals potential productivity).
- The co-domain of the cost inefficiency rate (*CIR*) is the interval [1, ∞). Rate 1 is reached when actual average costs equal potential average costs. This can be reached in specific cases when actual productivity equals potential productivity. However, if technical efficiency diminishes away from its potential level, average costs rise above the potential ones. As described in the previous paragraph, zero technical efficiency causes infinite cost inefficiency. Therefore, the co-domain of cost inefficiency rate has no upper frontier.

According to the results discussed, two conclusions which demonstrate the inverse relationship between technical efficiency and cost inefficiency can be deduced:

- If technical efficiency rises towards 1, cost inefficiency decreases towards 1.
- If technical efficiency decreases towards 0, cost inefficiency grows towards ∞.

The description of the relationship between technical efficiency and cost inefficiency can be deduced from any basic or advanced literature on microeconomics production and cost functions. This literature also offers sufficient methodological frameworks on the measurement of technical efficiency and cost inefficiency. What is interesting, and has attracted our attention, is the existing dichotomy in measuring both parameters. Although the cost inefficiency is the consequence of the reached technical efficiency, the existing methodological frameworks do not estimate cost inefficiency directly from observed technical efficiency. We recognized this problem by conducting several applicative researches for companies that perform automated production processes and measure their technical efficiency in real time by using *OEE* methodology. It is in fact this extensive use of the *OEE* framework in industrial management that raises the question of how to obtain cost inefficiency measurements directly from *OEE* in real time. For this purpose we conduct extensive theoretical and applicative researches with the aim of developing new algorithm that provides the answer to the stated question – we have developed an algorithm that estimates cost inefficiency rates directly from the technical efficiency rates obtained. Its development is described in the following section.

OVERALL COST EFFICIENCY (OCE) - ALGORITHM AIMED AT TRANSFORMING TECHNICAL EFFICIENCY INTO COST INEFFICIENCY

The term Overall Cost Efficiency (*OCE*) was proposed by us. We proposed the name according to the fact that this parameter is deduced from the key performance indicator *OEE* that measures overall equipment efficiency (or the so-called technical efficiency).

In microeconomics analyses of the cost function we have to distinguish between fixed and variable costs. Fixed costs are independent of the production amount, while variable costs vary with the production amount. Typical fixed costs are for example costs of labour force. We have to pay the worker for his daily work, although the machine was operating only a half of his working time. This has an influence on fixed costs per unit of the product (average fixed costs), which are mathematically calculated as:

$$AFC = \frac{FC}{TP}. \tag{11}$$

Symbols: *AFC* – average fixed costs,
FC – fixed costs,
TP – actual total product.

Following the above specified definition equation of average fixed costs, we can establish that *AFC* continuously diminish towards 0 if TP increases towards ∞.

On the other hand, costs of material are typical variable costs, since the consumption of material depends on whether the machine is in operating position or not. Therefore the average variable costs are constant per unit of final product. Mathematically they are calculated as:

$$AVC = \frac{VC}{TP}. \tag{12}$$

Symbols: *AVC* – average variable costs,

VC – variable costs,
TP – actual total product.

If we sum up average fixed costs and average variable costs, we obtain average costs:

$$AC = \frac{TC}{TP} = \frac{FC + VC}{TP} = \frac{FC}{TP} + \frac{VC}{TP} = AFC + AVC. \tag{13}$$

Symbols: *AC* – average costs,
TC – total costs,
TP – total product,
FC – fixed costs,
VC – variable costs,
AFC – average fixed costs,
AVC – average variable costs.

Note: In this case we do not distinguish between actual and potential total product.

When deducing *OCE* from *OEE* we have to be aware that changes in availability (*A*), performance (*P*) or quality (*Q*), which determine the *OEE*, differently impact production costs. If we accept the above described system of average fixed and average variable costs, the following axioms about the impact of availability, performance and quality on average costs can be defined:

- Decreasing availability (*A*) raises average fixed costs, while average variable costs remain unchanged. As we know from (2), the decreasing availability is a consequence of decreasing effective operating time. The decreasing effective operating time-span has no impact on the consumption of variable production factors (such as raw materials, or energy). The only consequence is reduced actual total product – the actual amount of production is below the potential level. Since fixed costs remain unchanged, the diminishing total product causes growth of average fixed costs – see (11). Hence, the changes of availability cause changes of average costs only via changes of average fixed costs.
- Decreasing performance (*P*) raises average fixed costs, while average variable costs remain unchanged. Following the definition equation of performance rate (3), the decreasing performance is a consequence of the decreasing actual production speed. The decreasing actual production speed has no impact on the consumption of variable production factors. Hence, the only consequence is reduced total product – the same impact as this occurs in the case of reducing availability. Therefore, the changes of performance cause changes of average costs only via changes of average fixed costs.
- Decreasing quality (*Q*) raises average fixed costs as well as average variable costs. The decreasing quality rate implies growth of the amount of bad pieces of production in the total product. Therefore the actual amount of production is below the potential one, which causes, according to definition equation (11), growth of average fixed costs. However, production of bad pieces of production has also an influence on average variable costs. When calculating the actual average costs we have to multiply the costs of variable production factors inherent to good pieces also with costs of variable production factors inherent to bad pieces. Hence, changes of quality have additional effects on cost inefficiency. The first impact is via increasing average fixed costs (as in the case of availability and performance), and the second impact is via average variable costs.

So, generally, changes in availability rate and performance rate influence only average fixed costs, while quality rate has an impact on average fixed costs as well as on average variable costs. These facts are an integral part of the *OCE* algorithm proposed below. By evaluating the algorithm we have to be aware about definition of the following symbols:

TP – actual total product,
Q – quality rate,
A – availability rate,
P – performance rate,
TC – total costs,
VC – variable costs,
FC – fixed costs,
AC – average costs,
AFC – average fixed costs,
AVC – average variable costs.
min – minimum,
max – maximum.

We start the development of the *OCE* algorithm by using the definition equation of cost inefficiency rate (10), and introduce some rearrangements by using (11), (12) and (13):

$$CIR = \frac{AC}{AC_{\min}} = \frac{\left(\frac{FC}{TP}\right)+\left(\frac{VC}{TP}\right)}{\left(\frac{TC_{\min}}{TP_{\max}}\right)} = \frac{\left(\frac{FC}{TP}\right)+\left(\frac{VC}{TP}\right)}{\left(\frac{FC}{TP_{\max}}\right)+AVC_{\min}} \tag{14}$$

Note: The condition $AVC_{\min}$ implies full quality.

If we introduce *OEE* into (14), we transform *CIR* into the *OCE* algorithm that calculates costs inefficiency from technical efficiency (*OEE*):

$$OCE = \frac{\left(\frac{FC}{TP_{\max}OEE}\right)}{\left(\frac{TC_{\min}}{TP_{\max}}\right)} + \left(\frac{AVC}{AFC_{\min}+AVC_{\min}}\right). \tag{15}$$

Note: $TP_{\max}$ multiplied by availability rate (*A*), performance rate (*P*) and quality rate (*Q*), i.e. with OEE, gives actual total product (*TP*).

$$OCE = \frac{\left(\frac{AFC_{\min}}{OEE}\right)}{AC_{\min}} + \left(\frac{AVC}{AFC_{\min}+AVC_{\min}}\right) \tag{16}$$

$$= \frac{1}{OEE}\cdot\frac{AFC_{\min}}{AC_{\min}} + \frac{AVC}{AC_{\min}}.$$

The equation (16) is the first definition equation of our algorithm aimed at transforming technical efficiency measured on the basis of *OEE* into cost inefficiency measurement. The

term $\frac{1}{OEE}$ implies the known inverse relationship between technical efficiency and cost inefficiency.

However, *AVC* can be expressed also as:

$$AVC = \frac{VC}{TP} = \frac{AVC_{\min} \cdot TP_{\max} \cdot A \cdot P}{TP_{\max} \cdot A \cdot P \cdot Q} = \frac{AVC_{\min}}{Q}. \tag{17}$$

By introducing (17) into the (16) we can deduce the final *OCE* algorithm:

$$OCE = \frac{1}{OEE}\left[\frac{AFC_{\min}}{AC_{\min}}\right] + \left[\frac{\left(\frac{AVC_{\min}}{Q}\right)}{AC_{\min}}\right] \tag{18}$$

or

$$OCE = \frac{1}{OEE}\left[\frac{AFC_{\min}}{AC_{\min}}\right] + \frac{1}{Q}\left[\frac{AVC_{\min}}{AC_{\min}}\right]. \tag{19}$$

The equation (19) is the final solution to our research problem. As we can see, there is an inverse relationship between *OCE* and *OEE*, where quality rate has an additional impact via variable costs.

The specification (19) is a mathematically deduced estimator that transforms technical efficiency into cost inefficiency in real time. There are four factors that determine the impact of technical efficiency on cost inefficiency:

- The first impact is controlled by the inverse value of *OEE* ($0 \le OEE \le 1$). Therefore, if *OEE* diminishes towards 0 the inverse value of *OEE* rises towards infinity, and if *OEE* rises towards 1, its inverse value diminishes towards 1.
- The second impact is controlled via the share of fixed costs in total costs. The domain of this ratio is [0, 1] – it is zero if total costs are variable, and it is 1 if total costs are fixed costs. The greater the share of fixed costs in total costs, the higher the impact of technical efficiency on cost inefficiency.
- The third impact is controlled via the inverse value of quality rate. The domain of the inverse ratio is between $[1, \infty)$. It is 1 in the case of full quality, while decreasing quality rate causes its growth towards ∞.
- The fourth factor is controlled via the share of average variable costs in average costs. The domain of this share is between [0, 1] – it is zero if total costs are fixed costs, and it is 1 if total costs are variable costs.

According to the developed algorithm, the above described four separate factors are actually united into two impacts that jointly determine the value of *OCE*.

- The first one is the impact of *OEE* jointly with the share of fixed costs in total costs. This implies that *OEE* determines the cost inefficiency only via fixed costs.
- The second one is impact of quality rate jointly with the share of variable costs in total costs.

This implies that all of the parameters incorporated in *OEE* have a unique impact on costs inefficiency via the fixed costs, but the quality rate parameter has an additional impact on cost inefficiency via the variable costs.

The equation (19) is also suitable for application in industry practice. According to the proposed algorithm only data on the shares of fixed and variable costs in average costs are needed. Since those shares are known from the normative calculations of average costs, the equation (19) is suitable for application in industrial management.

OCE FROM INDUSTRIAL MANAGEMENT POINT OF VIEW

From the industrial management point of view, two groups of main conclusions can be established.

First, the proposed new key performance indicator (KPI), termed as *OCE*, is an efficient tool that enables production management to control for cost efficiency of the production process in real time. By using the proposed *OCE* algorithm we can evaluate each factor that causes technical inefficiency of the production process from the costs point of view. Once we have the *OEE* measures we can deduce OCE measures that inform us by what percentage production is more expensive than it can be in the case of full technical efficiency.

Second, although there is a systematic and inverse relationship between technical efficiency and cost inefficiency, this relationship is not unique, but heterogeneous. Two simple examples can demonstrate this issue.

Example 1	**Example 2**
$A=1,\ P=1,\ Q=0.8,$	$A=0.8,\ P=1,\ Q=1,$
consequently $OEE=0.8,$	consequently $OEE=0.8,$
and if $\frac{AVC_{\min}}{AC_{\min}}=\frac{AFC_{\min}}{AC_{\min}}=0.5,$	and if $\frac{AVC_{\min}}{AC_{\min}}=\frac{AFC_{\min}}{AC_{\min}}=0.5,$
$OCE=\frac{0.5}{0.8}+\frac{0.5}{0.8}=1.25.$	$OCE=\frac{0.5}{0.8}+\frac{0.5}{1}=1.125.$

In both cases *OEE* equals 0.8, implying that the actual amount of production reaches 80% of the potential amount of production. But, in the first case the *OCE* equals 1.25, which implies that actual average costs (i.e. costs per unit of total product) are 25% higher than they are in the case of full technical efficiency. And in the second case the *OCE* equals 1.125, implying that actual average costs are by 12.5% higher than they are in case of full technical efficiency.

So the same level of technical efficiency is related to different levels of cost inefficiency. And exactly this heterogeneous nature of the causal relationship between *OEE* and *OCE* is the basic argument in favour of introducing *OCE* in the industrial management praxis. This is inevitable, because efficiency improvements demand additional investments and, as we have demonstrated, it is quite possible that we may achieve large improvements in technical efficiency but will achieve only a small reduction in cost inefficiency. Therefore an efficient and successful industrial management needs to upgrade the *OEE* framework with the proposed *OCE* methodology.

PILOT CASE STUDY – PRODUCTION OF PÂTÉ

The pilot case study was made in a company which produces pâtés in Slovenia. The production line of pâtés is organized as an integrated system of four production processes.

- The first phase is the preparation (cooking) of meat.
- The second phase is the preparation of the meat mass (pâté). They add oil, spices and water to the prepared cooked meat from the first phase. This phase represents the beginning of the automated production process which continues into the filling in the containers.
- The third phase is filling in the containers with the pâté prepared in the second phase, and the transportation of those doses-containers to the sterilisator. First three phases represent the closed process from the technical point of view. If the production process in some of those phases stops, all other two phases stop, too.
- The fourth and the last phase is transportation of containers from the sterilisator and packaging of doses. If the transportation of containers from the sterilisator is stopped then also the packaging is stopped.

The whole production process is thus integrated and allows no by-passes which could prevent the transmition of interruptions from past onto next phases of production. The only such by-pass could be from filling in the containers to the packaging – there are namely four sterilisators which enable almost uninterrupted process of packaging.

From the viewpoint of technical efficiency all phases of the production process should be efficient, as the main aim is to ensure uninterrupted production. From the viewpoint of cost efficiency however the crucial phase is the last phase – the packaging of containers, as the 100 % of the technical efficiency of this phase can neutralise inefficiencies of former phases. This is why we concentrate only on the process of packaging of containers.
The observations and measurements of technical and cost efficiency on the packaging line were made between July 7 and November 30, 2008. First we have calculated the parameter OEE:

$$OEE = A \cdot P \cdot Q,$$

where individual parameters measure: A - Availability, P - Performance, Q - Quality.

Availability (A)

The availability rate measures the relationship between the effective and total operating time:

- The daily working time is 16 hours (2 shifts).
- The total operating time is the daily working time less planned interruptions. As planned interruptions amount to 2.4 hours per day, the total operating time is 16 – 2.4 = 13.6 hours per day (this is constant).
- The effective operating time is the total operating time less unplanned interruptions.

The availability rate (A) thus measures the percentage of the time in which the production line is actually available for production process (Figure 2).

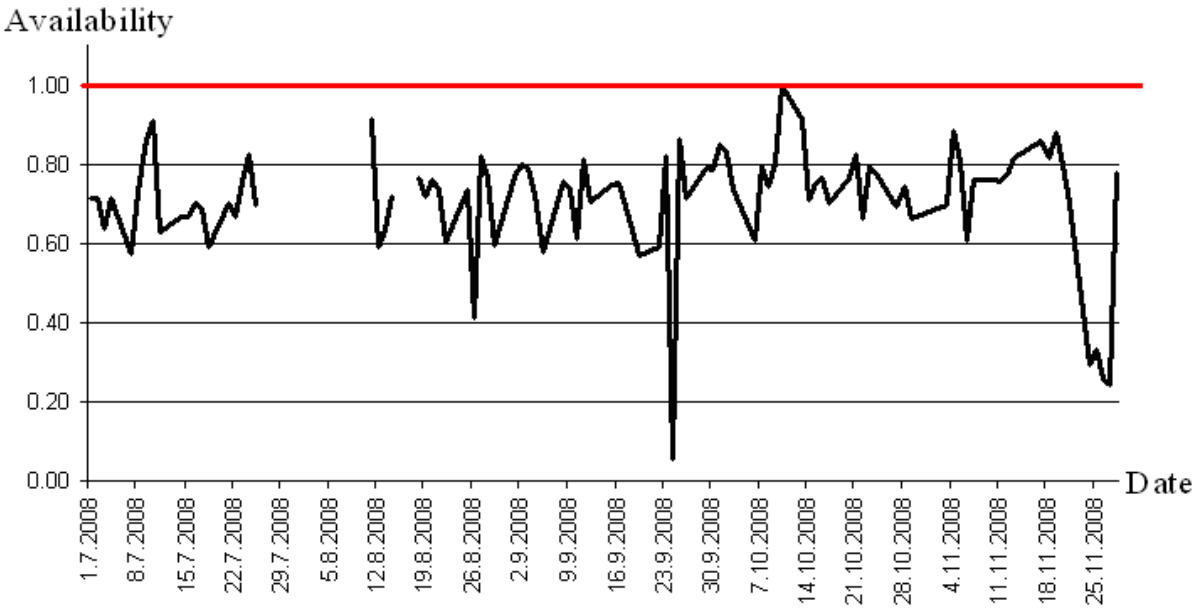

Figure 2: Availability rate of the packaging line (potential available time = 13.6 hours, number of observations: n = 95).

On the basis of 95 measurements we can conclude that the availability rate of the production line of packaging amounted on average to 71.23 %.

Performance

The performance rate (*P*) is a relative coefficient with an actual production speed (*APS*) in the numerator and a potential production speed (*PPS*) in the denominator. The performance is measured within the time frame of actual availability of the production line (Figure 3).

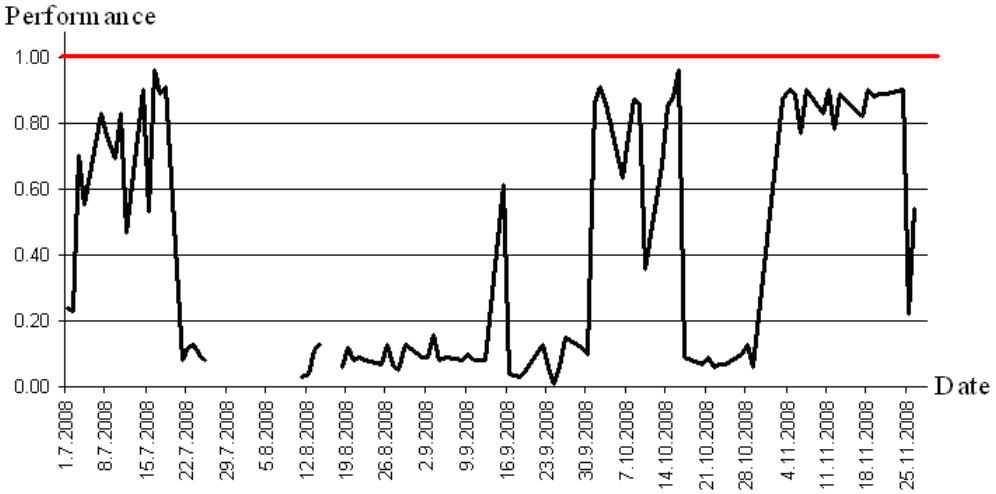

Figure 3: Performance rate of the packaging line (according to actual available time; number of observations: n = 94).

On the basis of 94 measurements we can conclude that the average value of the parameter P was 39.23 %. This means that on average the actual speed of the production line was by almost 60% lower than its potential speed within the actual available time of the production line.

Quality

This parameter measures the share of good pieces of production in the total production realized within the effective operating time and at the given performance of the production line.

As the analysed company was not measuring the quality rate in real time, we had to calculate it on the basis of previous production. We introduced the calculated rate of 98% as constant (Figure 4).

It must be stressed that the measurement of the parameter Q can not be limited only on the phase of packaging but must include the whole production process. This is because the parameter Q influences average fixed costs as well as average variable costs.

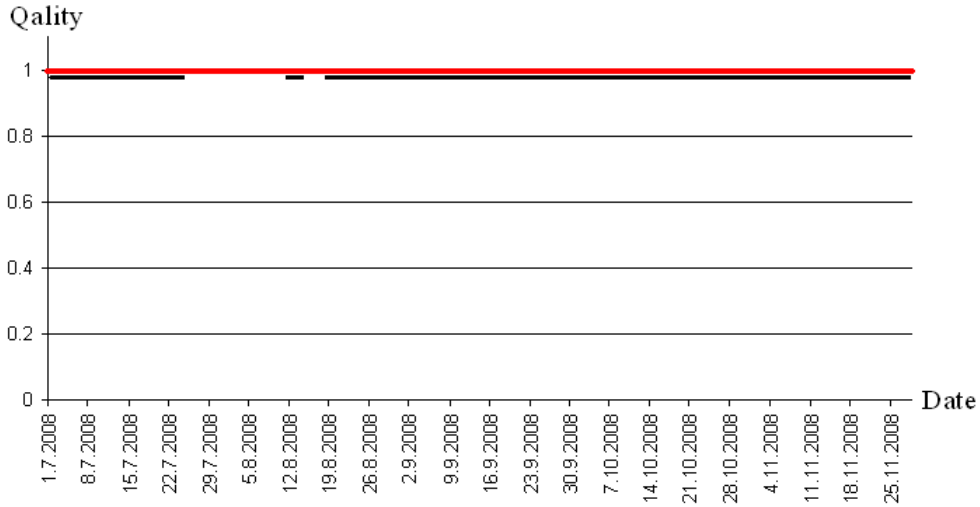

Figure 4: Supposed constant value of the parameter Quality for the whole production.

OEE

Parameter OEE measures the level of technical efficiency in the interval [0, 1]. Increasing value of OEE towards 1 means increasing (improving) of technical efficiency, and vice versa.

The average value of parameter OEE was 0.2915. It means that the actual quantity of production reached on average a little less than 30% of the potential amount of production in the observed period (Figure 5).

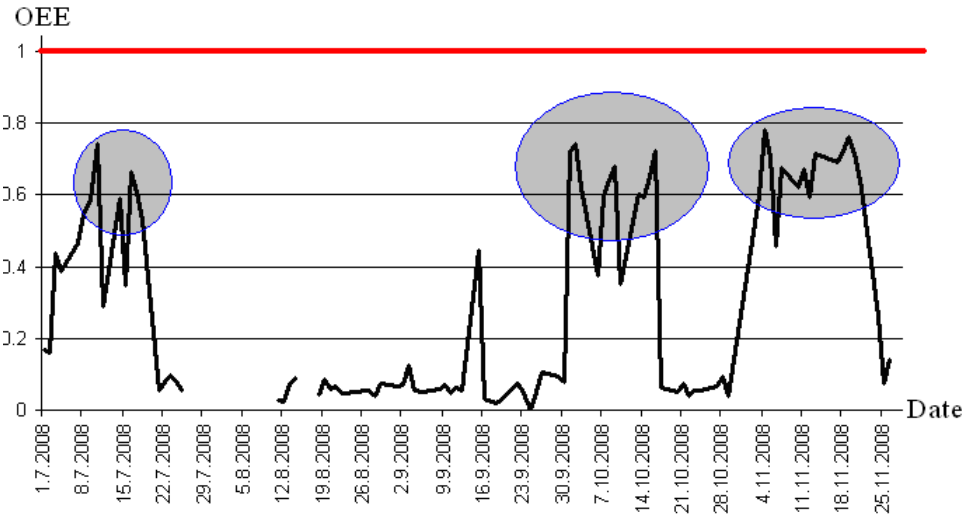

Figure 5: Values of parameter OEE for the packaging line of pâtés (number of observations: n = 94).

Very low average value of the parameter OEE is the consequence of low values of OEE in summer period of production. If we remove the values of OEE in the summer period and some extreme daily falls of the OEE and take into consideration only observations marked with gray, we get the average value of OEE = 0.6861. It means that the actual quantity of production reached a little less than 70% of the potential amount of production.

OCE

The relationship between the cost efficiency (OCE) and technical efficiency (OEE) is defined through equation:

$$OCE = \frac{1}{OEE}\left[\frac{AFC_{\min}}{AC_{\min}}\right] + \frac{1}{Q}\left[\frac{AVC_{\min}}{AC_{\min}}\right]. \tag{19}$$

OCE is the parameter which shows by how much percentage point the actual average costs exceed the potential minimal average costs. The potential minimal average costs would be achieved in the case of total technical efficiency (OEE = 1).

When estimating the cost efficiency the essential point is shares of fixed and variable costs in total costs. These shares are known from the normative calculations of average costs. Given the fact that the company produces some varieties of pâtés (chicken, tuna, salmon) these calculations are different for each product. But the average relation between costs is the following: 20% fixed costs and 80% variable costs. This ratio was supposed in our estimations of cost efficiency (Figure 6).

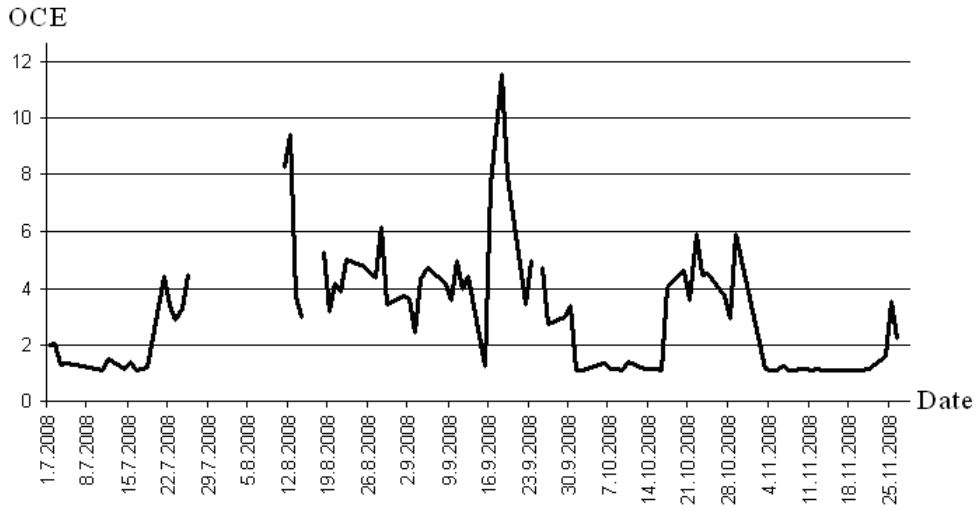

Figure 6: Estimations of cost efficiency (OCE) of packaging line of pâtés (number of observations: n = 93).

Supposing that all measurements of availability and performance of the packaging line are correct we must conclude that the average value of parameter OCE is 2.99. This means that the actual average costs exceed the potential minimum average costs by almost 3-times.

On the basis of our calculations of OEE and OCE we proposed some short term and long term measures to the management.

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PRODUCTIVITY MEASUREMENT AND DEVELOPMENT IN CONSTRUCTION INDUSTRY

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ABSTRACT

A lot of research has been done in the field of productivity because of its importance to the general well-being of the society. Productivity is often measured at a macro level which means the level where companies and industries operate. These research results are often considered controversial and the truth is that they often fail to fully explain the reasons behind the results. This paper explains the basic meaning of productivity and terms it is so often confused with. This paper also discusses the nature of productivity measurement and analyses the state of productivity in Finnish construction industry using data available in public. The implications of this research are that Finnish construction industry is doing all right when compared to its international counterparts, but is behind when compared to other industries in Finland. It is suggested that productivity should be approached at micro level where the physical change that is needed for productivity improvement takes place. Measurement should always pay attention to reliability and comparability of results, which means that the methods need to be standardized. As productivity is affected by many different factors and it is not useful as a measure in developing or in proactive management, the holistic set of different kind of performance measures should be used. This would ensure that the up-to-date information from the beginning of the cause-and-effect chain is taken into account when making management decisions.

Keywords: Productivity, Performance, Measurement, Management

INTRODUCTION

It is argued that productivity is perhaps one of the most important basic variables governing economic production activities (Singh et al., 2000; Tangen, 2005). Productivity development has a great importance on society for at least two reasons. Firstly, gains in productivity means that companies can increase wages without increasing prices, which in turn makes more money available for everyday spending (Fiume and Cunningham, 2003). Secondly, it is also one of the competitive advantages of companies who need to realize that gains in

productivity are one of their major weapons to achieve advantages on cost and quality over their competitors (Grossman, 1993; Tangen, 2005).

Because of its importance on well-being in a society, productivity has been widely discussed and researched since the beginning of the industrialization and even before. The performance of the construction industry has also been assessed with many studies from the productivity viewpoint (e.g. Allen, 1985; Rojas and Aramvareekul, 2003; Abdel-Wahab et al., 2008; Productivity Taskforce, 2009). The results from studies on different industries are often compared to each other, but that kind of macro level comparisons usually fail to explain the reasons behind the often so debatable results. Thus, some have even questioned the reliability and validity of the results and data used (i.e. Rojas and Aramvareekul, 2003; Sneck et al., 2007). Valid or not, people often seem to get on their back foot ahead of criticism directed on industries they work.

The term productivity is commonly used by both academics and practitioners, who however rarely give an adequate definition or explanation to it. Consequently, productivity is often mixed and used interchangeable with similar terms like performance or profitability (Sumanth, 1998; Tangen, 2005). In fact, misunderstandings may lead to measurement and improvement regimes built without a clear understanding what is going to be measured or improved. And ultimately opportunities to fully understand and optimize important factors relating to competitiveness and success can thus be missed. (Tangen, 2005).

In this study, the concepts of productivity, profitability and performance are clarified and the state of productivity in Finnish construction industry is analyzed. Analysis utilizes information available in public EU KLEMS database. And finally, the approach on productivity development is proposed. The paper aims to provide answers to the following research questions:

RQ1: What is the state of productivity in Finnish construction industry in relation to other industries in Finland and international counterparts?

RQ2: How the concept of productivity should be approached in construction industry?

PRODUCTIVITY – AN AMBIGUOUS CONCEPT

Productivity can be conceptualized as a system, which transforms inputs into outputs. In short, productivity is generally defined as a ratio between output factors and input factors of a system. Output is the outcome of the process – a product or service, and input factors consists of the resources used in a process of generating output factors. (Sumanth, 1998). According to The European Association of National Productivity Centres (2005) productivity expresses how efficiently and effectively products and services are being produced. Efficiency in this context means “doing things right” while effectiveness is often described simply as “doing the right things” (Grünberg, 2004). However, these kind of basic ratios are often regarded too “wide” to be useful in practice and there are numerous other definitions available.

Definitions for productivity are dependent on the reviewer point of view and the context within it is used. Generally verbal definitions aim to explain what the concept of productivity means while the mathematical definitions, on the other hand, can be used as the basis of performance measures, where the major aim is to improve (not to explain) productivity (Tangen, 2005). Some of the measures define productivity from different aspects depending on which input factors of production are taken into account. Approaches vary between the prevailing partial productivity that considers only one input factor (usually labor) at a time and total productivity, which tries to take all input factors into consideration (Sumanth, 1998).

Referring to Bernolak (1997) Tangen (2005) has highlighted two important characteristic of productivity. First, it is closely related to the use and availability of resources. This means that a company's productivity is reduced if its resources are not properly used or if it is short of them. Second, productivity is also strongly connected to the creation of value. Thus, high productivity is achieved when activities and resources used in process add value to the produced goods. Therefore one must eliminate waste in order to improve productivity: waste can be considered opposite of what productivity symbolizes.

Profitability

Productivity is often mixed with terms similar to it. One of them is profitability which is a crucial indicator for a company because it tells if the company is making money with its business or not. The difference between these concepts is that profitability has focus on money process, while productivity relates to physical phenomena in a real process. Still, productivity is often expressed and measured in monetary units per inputs as in many cases it seems to be only practical way (Stainer, 1997).

A significant issue is that profitability can change for reasons that have little to do with productivity. This is why productivity is considered a more suitable measure to monitor manufacturing excellence in the long run rather than profitability, since profits are influenced by many factors over the short term. (Miller, 1984; Tangen, 2005). Profit changes can be split into effects caused by changes in productivity, in sales activity and in price recovery (Van Loggerenberg and Cucchiaro, 1981). This is illustrated in Figure 1.

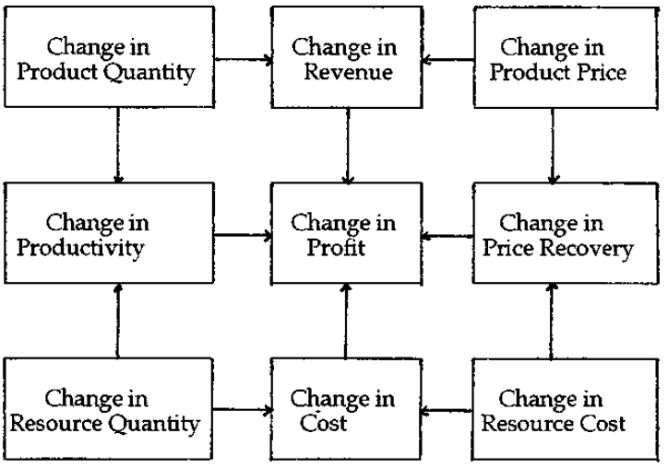

Figure 1: Productivity, profitability and price recovery (Van Loggerenberg and Cucchiaro, 1981).

Profitability does not have a direct impact when it comes to improvement purposes, since it is a result of, rather than a contributor to, the actions and processes in operations. A company can increase its profits and at the same time decrease profitability because monetary effects. But profitability is a useful addition to performance and productivity since it helps to identify the effects of monetary effects and distinguish them from "true" performance and productivity changes. (Grünberg, 2004).

Performance

Performance is the other concept that productivity is often confused with. Even though productivity is a multidimensional term, it is still a fairly specific concept related to physical phenomena in production. Performance, on the other hand is broader concept covering overall economic and operational aspects. It includes almost any objective of competition and manufacturing excellence whether it is related to cost, flexibility, speed, dependability or quality. "The triple P model" in the Figure 2 explains how the concepts of productivity, profitability and performance are related to each other. (Tangen, 2005).

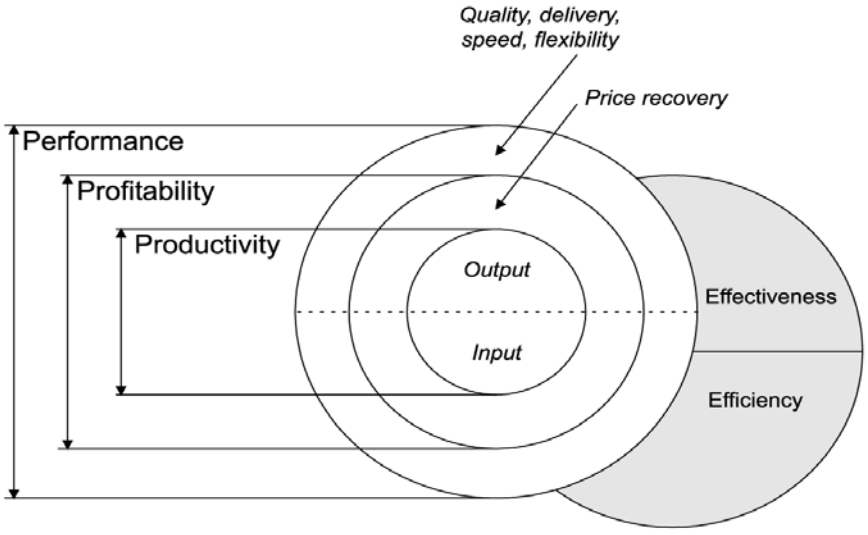

Figure 2: The triple P-model (Tangen, 2005).

Performance objectives often relate to a company's ability to compete and meet customer expectations. Some performance characteristics need to be sub-divided for easier measurement execution and they may turn out to resemble productivity measurements. It is suggested that a measure can be regarded as a performance measure if it is related to the five attributes mentioned in the previous paragraph. (Grünberg, 2004).

Measurement

Information from measurement is needed for two purposes: as a driver for internal improvement and for targeting and benchmarking projects and organizations (Koskela, 1992). A measurement system helps to reach long-term goals of an enterprise by connecting company objectives to improvements and setting targets for improvement activities (Grünberg, 2004). Indicators are defined in order to check the feasibility of the strategy and what kind of goals should be used on a daily basis (Haapasalo et al., 2006). Without knowing the impact of the decisions made it is difficult to improve productivity or any other important factor (Hannula, 2002). Yet, measurement should never become bureaucratic and inflexible or too supervisory from the employee perspective. It should provide practical information to the needs of management but with reasonable effort (Hannula, 2002). The ultimate goal of measurement should be to manage process, not results (Fiume and Cunningham, 2003).

Productivity can be measured at different levels: from broad economy and industry levels to very specific process or employee levels. At upper level financial indicators and physical measures are more common ways to describe the level and change of productivity. At lower levels there are numerous ways to keep track on productivity.

Problems considering broadness, allocation, comparability, value and measurement are characteristic to productivity measurement. The problem of broadness deals with the issue of which level of input and output should be taken into account when evaluating productivity. The problem of allocation instead occurs when deciding which input and output assets belong to the reviewing period. When comparing separate time periods with each other, the problem of comparability is faced. It is about eliminating price effect to make, for example, two sequential years comparable with each other. The problem of value is closely connected to the problem of comparability. It deals with the problem how the intangible assets and the value customer perceives are reported by quantitative means. The issue of selecting appropriate methods to achieve a high enough level of measurement accuracy occurs as the measuring problem. Broman (2004) refers to the commensurability problem, recognizing that each variable in the process is not measurable against the same standard or in the same units. Finding an appropriate way to solve the commensurability problem has resulted in various types of productivity measures and ways to aggregate inputs and outputs by use of weightings for example (Tangen, 2005).

In relatively many cases, especially at higher levels of analysis such as national and industry, productivity is being measured and indicated as labor productivity. This fact implies that industries characterized as labor intensive are not treated equally in relation to low-labor intensive industries. Comparing only labor productivity may not reveal productivity development in other factors.

To conclude, it can be said that productivity analysis at macro level (industry or economy) is a complex statistic process. This process includes lots of simplistic steps (e.g. deflation method) which aim at making data comparable over time and across enterprises and countries. To name a few, the following provides examples why such data is often incomparable (Mahony and Timmer, 2009):

- Data collection differences at national level.
- Labor input data does not cover all self-employed.
- Labor input data differs because of variations in contracts of employment.
- Multi factor productivity data differs depending on differences in vertical integration of firms.

When discussing about productivity analysis and growth accounting, Mahony and Timmer (2009) have put it in a simple form: *"…it should be emphasised that growth accounting is useful as a descriptive tool but that it is merely accounting and says nothing about causality."*

THE STATE OF PRODUCTIVITY IN FINNISH CONSTRUCTION INDUSTRY

Here, publicly available data from the EU KLEMS database was used for analyzing the state of Finnish construction industry from the productivity viewpoint. Analysis of the state of Finnish construction industry was made by comparing it to other main industries in Finland and its international counterparts. Industry classification is based on the EU KLEMS' classification of the main industry segments. Countries selected for international comparison were chosen to represent the considerable players in Europe (German and United Kingdom), Aasia (Japan) and United States. Denmark and Sweden on the other hand should ensure a good comparison with Finland, because of their location and size.

The EU KLEMS Growth and Productivity Accounts are financed by the European Commission to analyze productivity in the European Union at the industry level. The database has been largely constructed on the basis of data from national statistical institutes and is processed according to agreed procedures. It aims at moving beneath the aggregate economy level to examine productivity performance of individual industries and their contribution to aggregate growth. (Timmer et al., 2007).

Industry comparison in Finland

Figure 3 represents labor and total productivity development in the main industries in Finland over years 1970-2007. Both measures are based on gross value added per inputs. Input factor for labor productivity is hours worked while for total productivity capital, labor, energy, material and service inputs are taken into account.

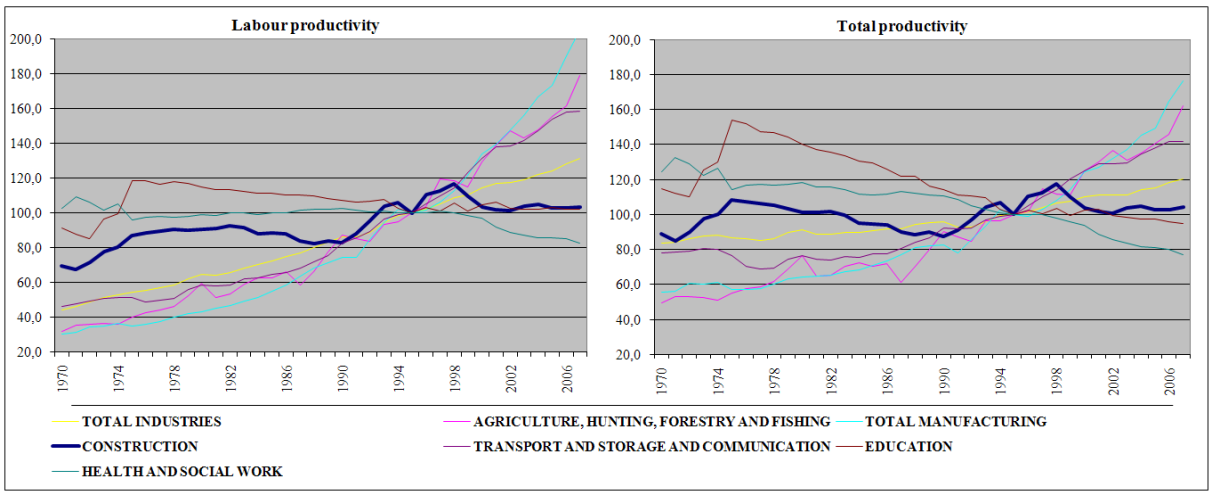

Figure 3: Labor and total productivity by industry in Finland, year 1995 = 100.

It appears that there are no big differences between labor and total productivity curves of a specific industry. And not surprisingly, most of the industries have positive trends. Still, there are industries that have stayed more or less the same over time and only education, and health and social work seem to have negative trend over longer time period. Surely productivity development efforts are done in every industry so how the negative trends are even possible? Because all graphs are based on indices (year 1995 = 100) it cannot be argued too deeply which industries are doing relatively better than others. Only the development rate between years can be learnt. Therefore, rather a few conclusions about the level of productivity of different industries can be made and even less can be said about causes behind the results. However, since the curves are rather smooth or having a smooth trend it seems that no individual innovation does play a remarkable role in productivity development. The trend of smooth development does imply that improvements are gained through continuous, step-by-step practices typical to lean thinking and described by i.e. Womack and Jones (2003) and Liker (2004).

The differences between industries are more likely to emphasize different business characteristics i.e. labor, capital or material intensiveness and maturity of the industry rather than inability or unwillingness to develop. Also the fact that monetary terms are mixed in productivity measurement should be considered. Remembering that the concept of productivity relates to physical phenomena it is even still variously expressed in monetary terms (Tangen, 2005). Surely every industry has better practices now than those used decades ago. It is also hard to believe that material, energy, capital or any physical efficiency would be so much worse now to explain declines over such a long time period. As Fiume and Cunningham (2003) have stated, changes in productivity requires physical change and thus cannot be made solely in the numbers from accounting or through financial engineering.

It can be concluded that construction industry has shown a steady positive curve compared to other industries, but it cannot match the development rate of the best ones and stays below the average of all industries. Construction industry can be considered a mature industry so it might be that there are fewer possibilities for improvement than in evolving manufacturing sector. Actually the newest of the industries, information technology, if separated from class of transport, storage and communications, would probably outpace

even the manufacturing sector itself. In other words, the different industries have a different development potential for small, continuous and natural development. IT sector benefits from constantly evolving products and it can take most out of the economies of scale. Also the value they provide to customers can outmuscle the cost of used resources hundredfold (e.g. in mobiles) which is not generally possible in construction. This in turn will come along to above figures if monetary terms are used to measure total output of industry.

International comparison of construction industry

Figure 4 provides international productivity development comparison in construction industry. Availability of data from each country differed slightly, thus curves can have different starting points. Input and output factors used are same as in industry comparison above. Both labor and total productivity were analyzed between the years of 1970 and 2007.

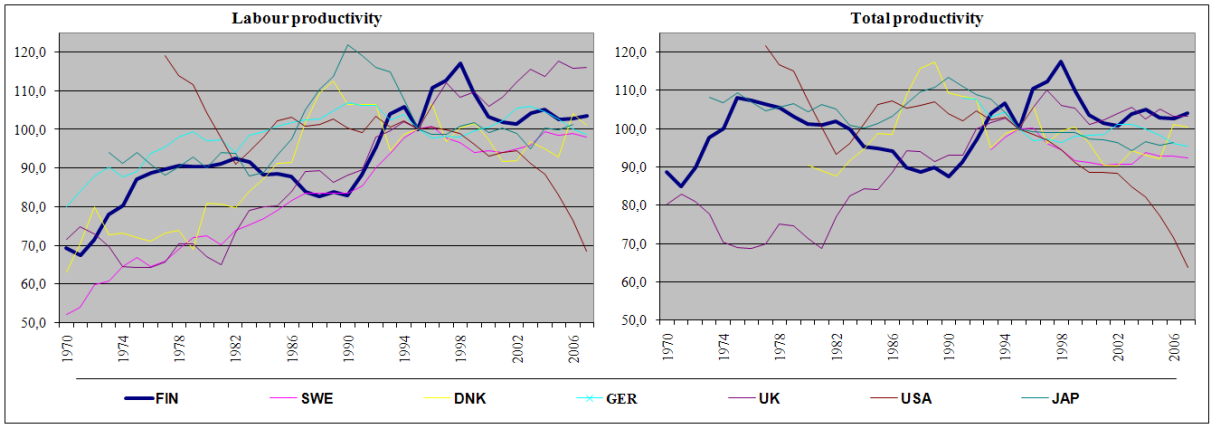

Figure 4: Labor and total productivity in construction industry, year 1995 = 100.

Figure 4 shows that the highest growth in labor productivity has been gained in Sweden, which has almost doubled its labor productivity during the period under review. United Kingdom and Denmark are slightly above Finland, but what is most striking is the long-term decline in the USA in both labor and total productivity. This seems a bit odd, concerning that other industries have remarkably better trends in both charts and raising doubts about validity of data used in this survey.

High up and down turns can be detected in this figure. Moreover, it seems that in general, growth in labor productivity has stopped or started to decline slightly between years 1989 - 1998. Alterations to the statistical procedures could be one explanation for such steep up and down turns, but they are unlikely to be the reason for long-term trends.

Productivity has increased more or less in some depth in all countries. The reversed case in the USA appears somewhat impossible. There must be differences in working methods and data collection at national level which can explain such movements. However, comparing countries within the same industry, providing same kind of products and services is more reasonable than conducting an economy-wide survey. Nevertheless, it is unclear whether or not the statistics are comparable with each other and which are the factors influencing

curves. Once again, it has to be noted that not many conclusions about relative productivity levels between the countries can be made based on these charts.

State of Finnish Construction Industry

Based on the above findings, it can be said that internationally, productivity development in Finnish construction industry has been slightly above the average level. It does not stand out as world class, but it is close to the industry's best performers. On the other hand development appears to have stopped from the year 2000 onwards, but the situation is same in the other countries too. In industry comparison the Finnish construction industry sets up slightly below average of the industry total, but its development curve appears to be steadily positive in long-term. Still the raise level is only about 1% in year during the last 30 years for labor productivity and less than half of that for total productivity. This may be the evidence of the maturity of the industry or the failing to embed the culture of continuous improvement and lack of tools to tackle other but value added activities on daily basis.

In general, construction industry has the same potential as anyone to eliminate its waste activities. It is true that the industry has its own peculiar characteristics like unique projects, site production and temporary multi organizations. (Koskela, 1992; Ballard and Howell, 1998). Also regulatory intervention of authorities can be considered one peculiarity (Koskela, 1992). But the emphasis on the construction industry is still too much on costs associated with materials and labor. In projects that are split in smaller and smaller pieces to be contracted this eventually leads to sub-optimization. To support this notion, Koskenvesa et al. (2010) state that the waste aspect is not paid enough attention to in the production planning and control processes in construction.

A lot have been said about the reasons of slow or declining productivity in construction industry. One interesting point was highlighted in the mid-1990s by Allen (1985) who explained the declining curves with a change that the industry has experienced. The outputs are changing a lot in the industry and emphasis is in different kinds of outputs now what it was decades ago. In general projects become more complex all the time. Teicholz (2001) states that productivity trends in different sectors of construction need to be better understood, because different sectors are most likely to be experiencing opposite kind of development in productivity. Also many firms who construct prefabricated units are classified as manufacturing firms, which in turn have experienced rapid development during the last decades.

Many more authors have given their contribution to identify the causes behind productivity development. Reduction of skilled labor, management capability, procurement, regulation and technology are only some of the reasons identified and discussed, but one which often comes up is the quality of construction work. It is mentioned that design problems constitutes almost half of the construction defects when measurement is done with the principle of "cost to correct". The other half splits almost equally between supervision and workmanship problems (Productivity Taskforce, 2009). Anyway, guidelines in construction set only the minimum level for quality (Saarenpää, 2010), which is opposite to the "zero defects principle" which forms the other basic pillar in lean thinking utilized in growing rate

in manufacturing firms all over the world. These kind of artificial acceptable quality levels are counterproductive and can only be striped with a cultural change towards quality.

IMPLICATIONS OF PRODUCTIVITY DEVELOPMENT IN CONSTRUCTION

In theoretical review on productivity it was stated that productivity is ambiguous concept which is usually used for macro level comparisons and to explain national growth. Analysis on Finnish construction industry showed that the development has been steady but slow and lack behind many other industries in Finland. Here are the main implications for productivity development learned in this study.

Focus to micro level measurement

When analyzing macro level productivity graphs one can only look backwards which is not of much help for improving productivity in future. The causes behind results stay hidden which leads to endless debate between the possible causes, and both validity and reliability of the results. Macro level approach to productivity is used to examine productivity performance of individual industries and their contribution to aggregate growth (Timmer et al., 2007) in relation to past performance of other nations or industries. Macro level measurement and measures based on monetary value are too rigid to be effective in developing productivity and too slow to help companies to make better decisions for the future.

Koskela (1992) have stated that measurement data is needed for two purposes: as a driver for internal improvement and for targeting and benchmarking projects and organizations. Measurement should always yield reasonable and comprehensible information in the first place as it is difficult to improve productivity or any other important factor without knowing the impact of decisions made (Hannula, 2002). Revealing root causes behind productivity and performance changes support this aim and since the physical change that is required for productivity increases takes place at micro level, it looks obvious to return closer to that level. Figure 5 shows examples of the levels productivity can be examined. Where macro level measurement is suitable in order to grasp a view of an overall situation, the bottom-up approach at a lower micro level is needed in order to seek and find real opportunities for productivity improvement.

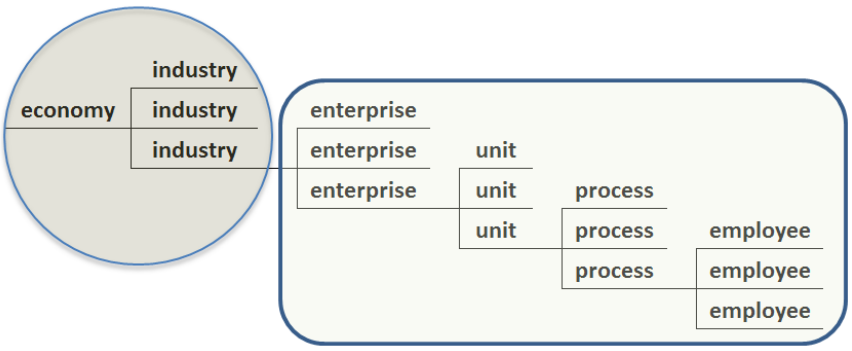

Figure 5: Levels for productivity examination.

Reliable and comparable results

In addition to reliability, measurement should provide also comparable results. Industry level productivity development programs could learn a lesson by following automotive industry's example. There an extensive benchmark study was conducted to develop the future of the industry in the late 1990s, which led to results describing how lean production system works in great detail. The comparability problem was taken seriously in that study and assembly was identified as a key activity in automotive manufacturing. Assembly was also a good choice because all plants over the world do almost exactly the same things, relying on very similar fabrication techniques. Within assembly a list of standard activities was further devised to be assessed and measured, making sure that they are comparing apples with apples. (Womack et al., 2007).

In construction there are similar possibilities to conduct wider studies to understand and then develop productivity. Even though there is no Toyota like example for the construction industry yet, it can be done to understand how the industry works as a whole. There are also similar characteristics of labor intensive work phases in design and assembly, and operations are also more or less based on similar fabrication techniques all over the world. On the other hand the practices vary between workers, companies and nations, which lead to the need of measurement method standardization, benchmarking and unifying the best practices within industry as part of the continuous improvement theme.

Only comparable information will give a real picture of any system at any level. In practice this means that definitions of what is being measured and improved must be done carefully and with great detail. The focus should be in factors that are important, but also measurable. This should be done without becoming too bureaucratic or inflexible, because measurement consumes resources as any other activity. Measuring should focus on critical factors affecting overall performance and it should be carried out with a reasonable amount of effort (Salminen, 2005).

Holistic measures drive productivity development

Productivity as a measure is complicated to use, because of so many base-level decisions what to include into outputs and inputs, and also how to carry out the measurement itself. The process is so complex that management decisions cannot be made according to results from productivity measurement. Instead, several performance factors do contribute to productivity and are also easier to define and measure. Using the formula of outputs-inputs can sometimes be deceiving in determining overall performance. Performance measurements that reflect the operational strategy of the company should be developed and used. (Singh et al., 2000). Therefore, performance development should be controlled and supported using a holistic set of performance indicators. Information about quality, costs, time, safety, leadership and motivation is usually available for this purpose, but still every company has to define its own indicators to match its long-term goals.

Stainer (1997) states that management must choose the productivity measure which would produce the most relevant information for their strategic decision making. Measurement should help companies to anticipate future, judge and fine-tune current performance and to

compare them to past performance. One way to approach this is balanced scorecard where financial performance shows the past, customer perspective and internal business processes the present and the measures for innovation and learning aim to anticipate the future (Kaplan and Norton, 1996). It is not that productivity itself would not be important, but the chain of cause-and-effect relationships (Figure 6) is suchlike that requires more flexible and up-to-date measures to enhance the productivity performance in the process.

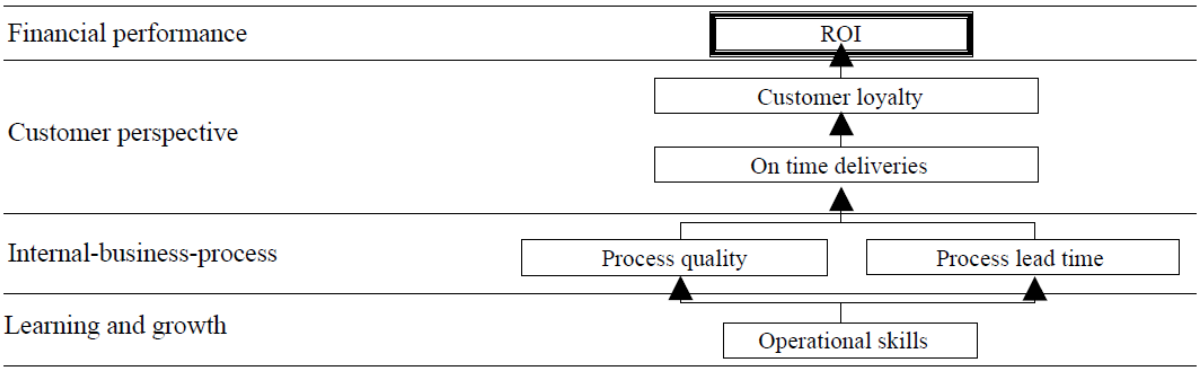

Figure 6: The chain of cause-and-effect relationships through the BSC perspectives (Kaplan and Norton, 1996).

CONCLUSIONS

In this paper the basic meaning of productivity and its similar terms were explained. The characteristics of productivity measurement were considered and further tested in the analysis of Finnish construction industry. A lot of effort has been used in the past to study productivity at macro level which has led to controversial results and endless debate of their validity. This study does not even try to represent its own version of truth, but it shows how hard it is to interpret and compare macro level analysis. According to the results of this study, the Finnish construction industry does basically all right when compared to its international counterparts. The comparison to other industries in Finland shows that the productivity development has been steady for long time, but not as rapid as it has been in some other industries. Implications from multi-dimensional characteristics that productivity has and from productivity development analysis in construction industry are, that the productivity should be approached at micro level and with more physical measures to reveal causes behind good and bad performance. Then the reliability and comparability of the results should be ensured by standardizing measurement methods within scope and measurement period. At last but not least, the use of holistic set of performance measures is recommended as productivity itself seems to be affected by many different factors, but as a measure it is too rigid and slow to be useful in developing and proactive management.

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F3 – Performance management

F3.1 **Longitudinal modeling of the software engineering capabilities and profitability of software companies in Japan**
Dr. Yasuo Kadono

F3.2 **The impact of technology strategy on the performance of innovation – A case study of Chinese IC design firms**
Min Wang

F3.3 **The issue of the efficacy of the organisation operating in a multi-project environment**
Dr. Seweryn Spalek

F3.4 **What should be done for improving employee training performance? A human resource development perspective**
Dr. Hsiao-Chen Chang

LONGITUDINAL MODELING OF THE SOFTWARE ENGINEERING CAPABILITIES AND PROFITABILITY OF SOFTWARE COMPANIES IN JAPAN

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ABSTRACT

This study aims at better understanding the relationships among software engineering capabilities and profitability, as a representative business performance, of software vendors in the drastically changing IT industry in Japan. To do so, we designed a survey on software engineering excellence (SEE) and administered it in 2005, 2006 and 2007 with the Japanese Ministry of Economy, Trade and Industry. Then, we measured the SEE survey results with regard to seven factors: deliverables, project management, quality assurance, process improvement, research and development, human development, and customer contact. Based on the longitudinal modeling of the three-year SEE data and ten-year operating profit ratio of the 151 respondents to the SEE surveys, we significantly verified that IT firms who have excellent software engineering capabilities tend to improve their business performance in a medium- and long-term standpoint.

Keywords: software engineering capability, longitudinal modeling, social research

INTRODUCTION

Many companies that use enterprise software in Japan have not been fully satisfied with the quality, cost, speed and productivity of software that IT vendors deliver. At the same time, IT vendors in Japan are facing drastic changes in their business environment, such as technology innovations and new entrants from China, India and other countries. Also, the issues in the IT industry in Japan, such as the multilayer subcontractors and the business model depending on custom-made applications for domestic market orientation, have been pointed out over times (Cusumano, M., 2004; Kadono, Y., 2007).

The information service industry is a 10.5 trillion yen market in Japan, which includes 7.6 trillion yen in software development and programming. In 2009, orders for software totaled 6.4 trillion yen, accounting for 60.3% of the entire information service industry, while the software products market was 1.2 trillion yen (METI, 2010).

In order for the IT industry in Japan to meet these challenges, an important step is to understand how software engineering capability is significant as a core competence for achieving medium- and long-term success. Therefore, we designed the research on software engineering excellence and conducted it in 2005, 2006 and 2007 with Ministry of Economy, Trade and Industry, Japan.

As shown in Figure 1, the objectives of the research are to:

- assess the achievements of the Japanese software engineering discipline, as represented by IT vendors in Japan, and
- better understand the mechanism of how software engineering capabilities relate to IT vendors' business performance and business environment.

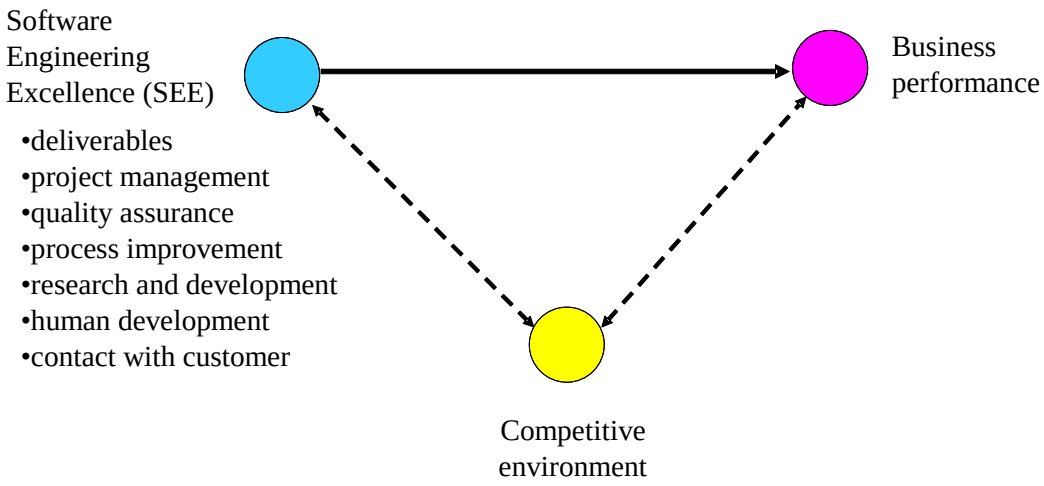

Figure 1: Conceptual model of overall SEE research.

To achieve these objectives, we developed a measurement tool called Software Engineering Excellence (SEE), which can evaluate the overall software engineering capabilities of IT vendors from the viewpoint of deliverables, project management, quality assurance, process improvement, research and development, human development, and contact with customers (Kadono et al. 2006). Also, we introduced other indicators: business performance and business environment. We assume that the business environment complements the relationship between SEE and the business performance of the software vendors.

In the SEE2005 survey, we analyzed the relationship among SEE, business performance and business environment based on the data collected from 55 major IT vendors in Japan. We conducted the path analysis, during which we found that SEE characteristics have a direct positive impact on business performance and that the competitive environment directly as well as indirectly (i.e., via SEE) affects business performance in the same year.

In the SEE2006 survey, we increased the number of surveyed Japanese IT vendors from 55 to 78 in order to more deeply investigate the impact of software engineering on business performance and the business environment. In particular, in this study we focus on the relationships among the SEE factors, the business environment, and business performance as measured by operating profit ratio in the same year (Kadono et al., 2007). By analyzing the data collected from 78 major IT vendors in Japan, we found that superior deliverables and business performance were correlated with the effort expended particularly on human resource development, quality assurance, research and development and process improvement at 5% significance.

In 2007, we analyzed the data collected from 100 major IT vendors in Japan. At that time, we reproducibly observed that the level of effort expended on human resource development, quality assurance and project management improved the performance of the IT vendors in Japan in customer contact, research and development and process improvement, the same tendency we found in 2006. However, we also observed that the causal relationships differ significantly depending on the vendors' origin, i.e., whether a business is a makers-turned vendor, a user-turned vendor or an independent vendor (Kadono, Tsubaki, Tsuruho, 2009).

In the previous paper (Kadono, Tsubaki, Tsuruho, 2010), we analyzed the relationships among the seven factors of software engineering capabilities and significantly verified the following results since human development and R&D should be statistically regarded as one concept, and the same aggregation can be suggested the relationship between project management and process improvement.

- Human development and R&D are significantly influential factors on the overall software engineering capabilities.
- Negative paths, e.g., from human development/R&D to deliverables, imply that effort invested in some factors did not pay off at least during the duration of this research. They might, however, be expected to have long-term effects. Otherwise, they might suggest the tradeoff between the factors, e.g., quality assurance and customer contact.
- The factors at the lower stream, e.g., deliverables, should be interpreted in relation to the other factors such as business environment and business performance.

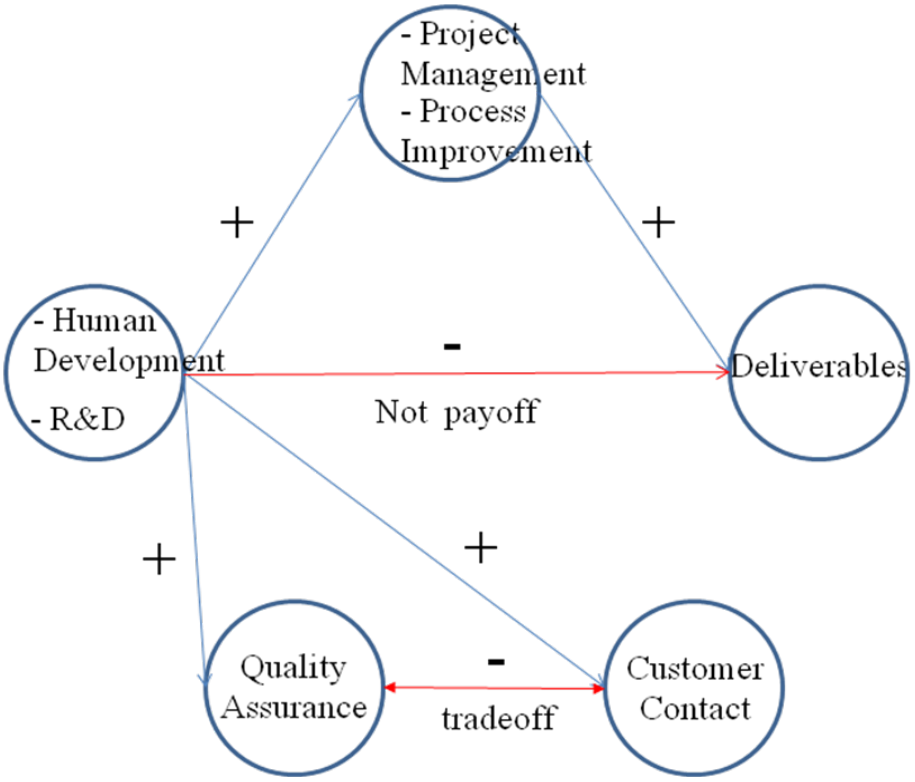

Figure 2: Implications of path analysis among SEE factors (Kadono et al., 2010).

Based on the above findings, the areas of software engineering should be managed in the future in the following way. First, human development and R&D should be considered to be fundamental capabilities to improve the quality of deliverables. Second, among the seven software engineering capabilities, improving project management and process improvement could be expected to be an immediate effect on deliverables. Third, on the contrary, quality assurance and customer contacts might need long-term efforts to be successful.
Therefore, based on the three-year SEE survey data, we verified that learning order effects among the seven software engineering capabilities contributes to software engineering improvement.

In addition to the analysis on the relationships among the seven SEE factors, in the present paper, we expand the research method to the analysis on the relationships between software engineering capabilities and business performance based on the longitudinal modeling. Here, we focus on the operating profit ratio as a representative business performance.

RESEARCH MODEL

We introduce the structural model and the measurement model of the research on software engineering excellence (SEE) in this section.

Structural model

Based on the interviews with successful IT vendors in Japan, we hypothesize that firms who have excellent software engineering capabilities tend to improve their business performance in a medium- and long-term standpoint. Therefore, we assume a path model as shown in Figure 3. Here, SEE consists of SEE2005, SEE2006 and SEE2007 and business performance is measured by a representative profitability factor, i.e., operating profit ratio, from 1999 through 2008 in this paper.

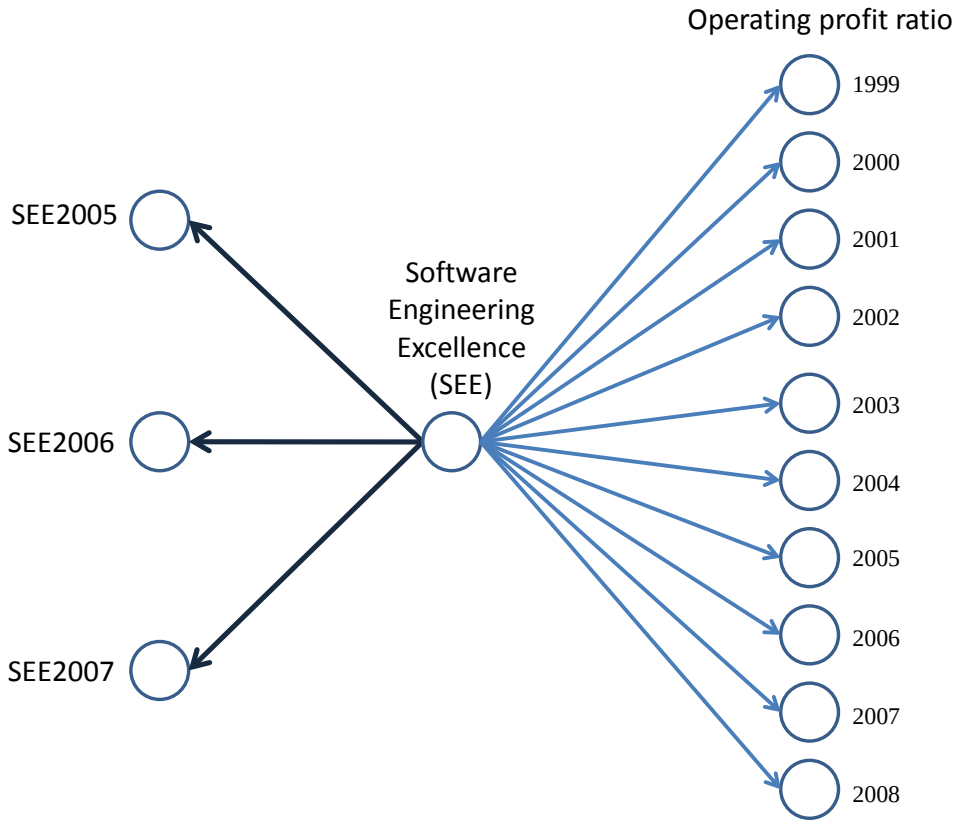

Figure 3: Structural model hypothesis.

Measurement model

Our measurement model of SEE was originally developed through interviews with over 30 industry experts in Japan and the U.S. as well as literature searches (Fujimoto, 2003; Matsumoto, 2005; Ministry of Economy, Trade and Industry, 2007). Since this research intends to encourage innovation, we surveyed state-of-the-art cases from the viewpoints of marketing, process, and product in order to develop our measurement model. Therefore, the scope of the survey includes intangible resources of vendors based on the resource-based view (Barney, 2007).

The SEE measurement model has a hierarchical structure with three layers: observed responses to question items, seven detailed concepts, and SEE as a primary indicator (Kadono et al. 2006). The measurement models for 2006 and 2007 were updated slightly based on the response rate of each question item, the statistical significance of each observed response to the 2005 and 2006 SEE surveys, and changes in technology and market trends.

SEE as we have defined it consists of the following seven concepts:

- deliverables: achievement ratio of quality, cost, speed, and productivity, grip on project information.
- project management: project monitoring, assistance to project managers, project planning capability, ratio of PMP(Project Management Professional).

- quality assurance: organization, method, review, testing, guideline, management of outsourcers .
- process improvement: data collection, improvement of estimation, assessment method, CMM/CMMI (Carnegie Mellon University's Capability Maturity Model Integration).
- research and development: strategy, organization, sharing technological skills, learning organization, development methodology, intellectual assets, commoditized software, readiness to state-of-the-art technology.
- human development: training hours, skill development systems, incentive schemes, measure of human development, moral support.
- contact with customers: ratio of prime contracts, scope of service offered, direct communication with customer's top management, deficit prevention, clarification of user specification.

Regarding the operating profit ratio as a representative business performance, we uniquely identified 151 IT firms responding to the three SEE surveys and calculated their operating profit ratios from 1999 to 2008 according to the corporate information of a Japanese credit research firm. Based on the time series data, we estimate the intercept and the slope of the operating profit ratios of the respondents for ten years.

SURVEY ON SOFTWARE ENGINEERING EXCELLENCE

Based on the measurement model, we conducted surveys on Software Engineering Excellence in 2005, 2006 and 2007 with Japan's Ministry of Economy, Trade and Industry. We designed a questionnaire on the practice of software engineering and the nature of the respondent's company. This questionnaire was sent to the CEOs of major Japanese IT vendors with over 300 employees as well as the member firms of the Japan Information Technology Services Industry Association (JISA), and was then distributed to the departments in charge of software engineering.

Responses were received from 117 companies with a total of 100 valid responses to the 2007 survey, a response rate of 10%. There were 55 valid responses, a response rate of 24%, for the 2005 survey and 78 (response rate of 15%) for 2006. For this paper, we integrated the 233 valid responses received over the three years into a new database including 151 unique companies consisting of 42 maker-turned vendors, 33 user-turned vendors and 76 independent vendors (Table 1).

Table 1: Software engineering excellence surveys.

Year	2005	2006	2007	2005/06/07
Questionnaires sent	230	537	1000	NA
Valid responses	55	78	100	151
Maker-turned User-turned Independent	17 15 23	27 15 36	27 20 53	42 33 76
Response rate (%)	24	15	10	NA

After collecting data from the vendors in 2005, 2006 and 2007, we calculated the factor loadings of seven factors: deliverables, project management, quality assurance, process improvement, research and development, human development and customer contact, based on the responses received to the questions relevant to the measurement model described in the previous section (Kadono, Tsubaki, Tsuruho, 2009).

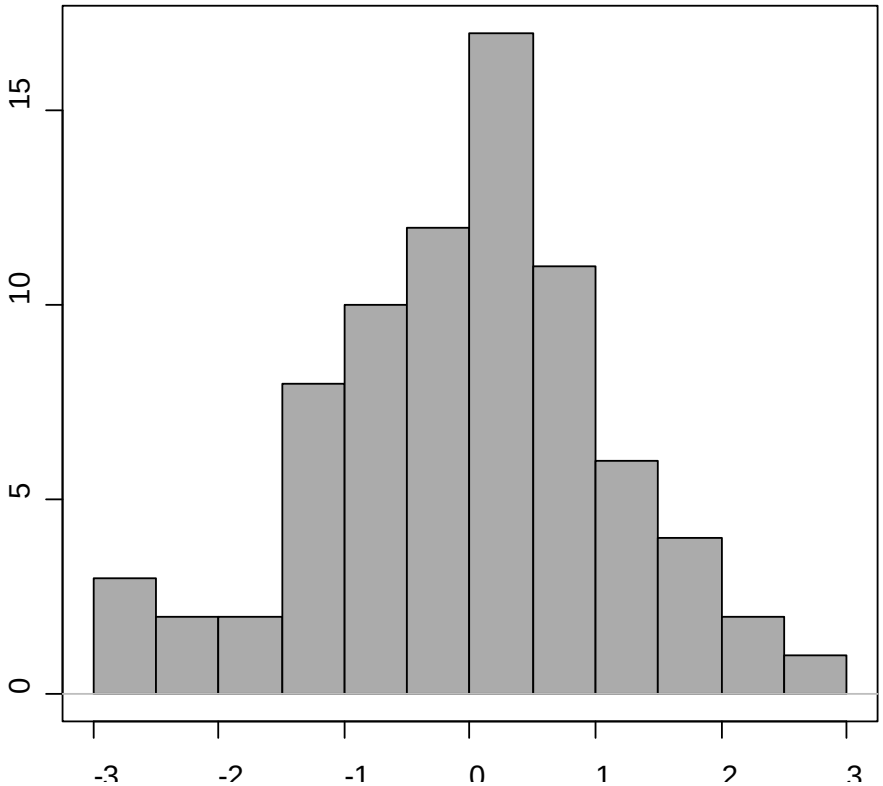

Figure 4: Histgram of deviation of SEE2006.

Then, the measurement model is fitted to the data by confirmatory factor analyses to estimate the score of SEE each year. For example, a histogram of deviation of the SEE2006 score is shown in Figure 4, and a scatter plot diagram matrix of the seven factors and SEE2006 is shown in Figure 5.

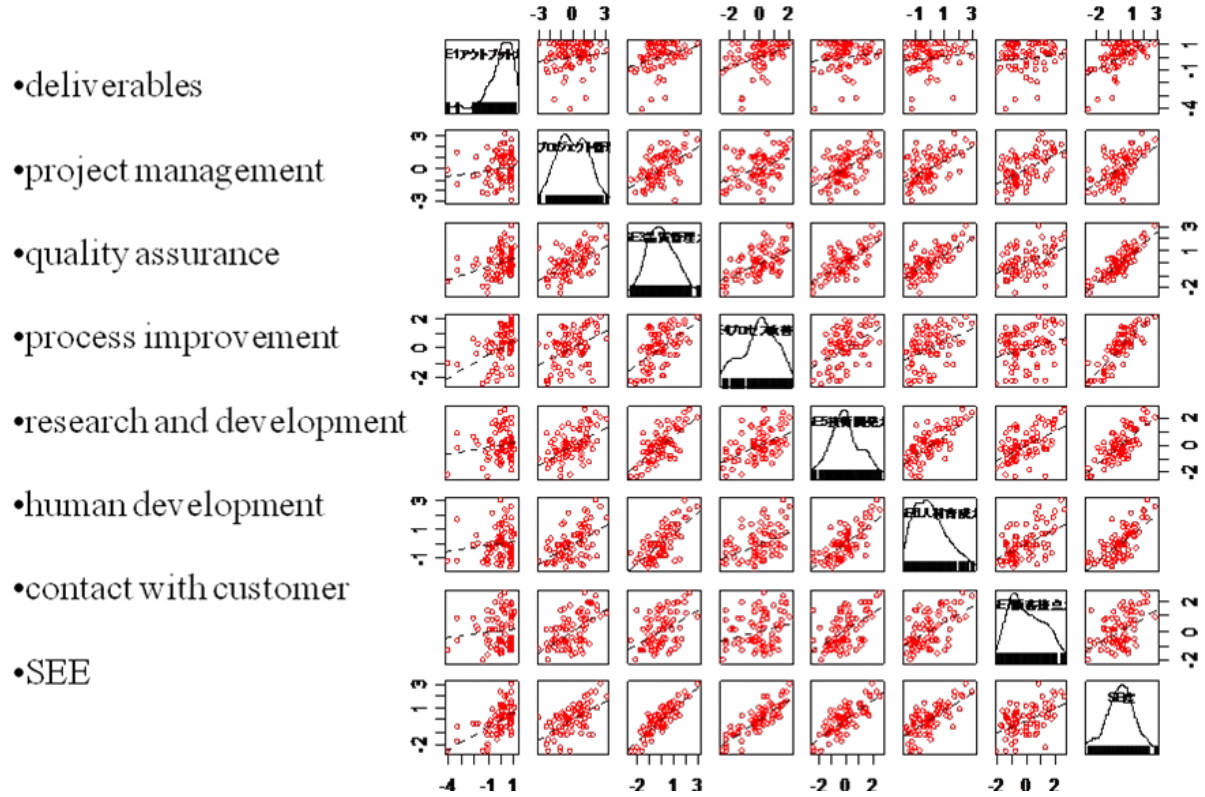

Figure 5: Scatter plot diagram matrix of the seven SEE factors and SEE2006.

In this paper we aggregate the three-year SEE scores, i.e., SEE2005, SEE2006 and SEE2007, to estimate overall SEE scores (Figure 3).

RESULTS

Based on the structural model hypotheses in Figure 3, we conducted path analysis of the data from the 233 valid responses we had received to the 2005, 2006, and 2007 surveys from 151 unique firms (Bollen, K. 1989). The result of the path analysis is shown in Figure 6. We found the following to be characteristics of the significant relationships among three-year SEE scores and ten-year operating profit ratios:

- Regarding SEE, overall SEE is relating to SEE2005, SEE2006 and SEE2007 at 0.1 % significance.
- Overall SEE has a positve impact on the intercept of operating profit ratio for ten years at 10 % significance.
- Also, overall SEE has a positve impact on the slope of operating profit ratio for ten years significantly at 5 % significance.
- The fittness of the model (CFI) is 0.415.

These results imply that the IT vendors with higher SEE, i.e., excellent software engineering capabilities, have improved their operating profit ratio in a medium- and long-term based on the ten-year financial data.

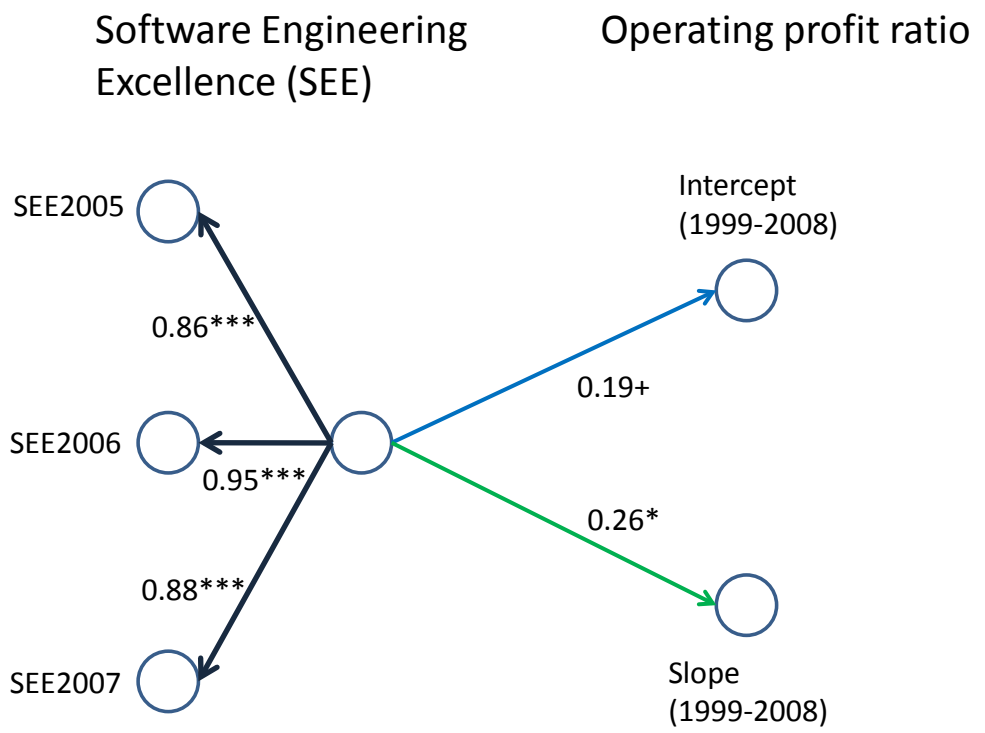

Figure 6: Path analysis results.

CONCLUSIONS

In the present paper, we significantly verified that firms who have excellent software engineering capabilities tend to improve their business performance in a medium- and long-term standpoint, based on the longitudinal modeling according to the data of three-year SEE surveys and ten-year financial data of IT vendors responding to the SEE surveys. In this paper, we focus on the relationships between overall SEE scores of the three surveys and the operating profit ratio as a representative business performance. For the future study, we would expand this longitudinal model so that we can analyze the relationships among the seven SEE factors, i.e., deliverables, project management, quality assurance, process improvement, research and development, human development, and customer contact, and other financial indicators such as the profitability and stability of management (Figure 7). The SEE part in the left-hand side of Figure 7 is the hypothetical model among the seven SEE factors adopted in the previous paper (Kadono, Tsubaki, Tsuruho, 2010).

Furthermore, the analysis of the relationships among SEE, business performance and business environment (Figure 1) e.g., number of software engineers, business model, and average age of employees, remains to be solved in the future.

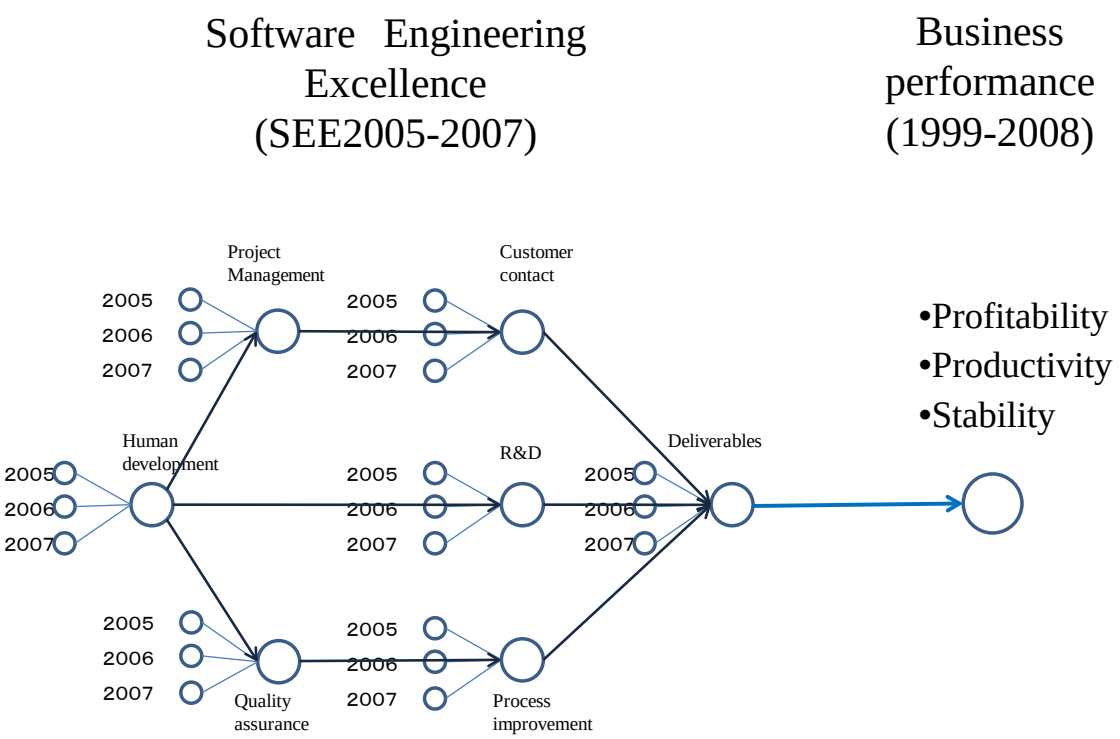

Figure 7: Hypothetical model of relationships between SEE and business performance.

ACKNOWLEDGEMENTS

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THE IMPACT OF TECHNOLOGY STRATEGY ON THE PERFORMANCE OF INNOVATION -A CASE STUDY OF CHINESE IC DESIGN FIRMS

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ABSTRACT

This paper comparatively analyzes the technology strategy of innovation and its performance among three Chinese IC (Integrated Circuit) design firms. The intention was to clarify how technology strategy affects the outcome of technology innovation in the process of catching-up. The research question was studied from four aspects such as technology selection, technology opportunity, technology monopolization and resources required for technology innovation. The results show that the selection of technology strategy is of great importance for Chinese IC design firms to catch-up by technology innovation.

Keywords: Fabless Design Firm; Innovation; Technology Strategy

INTRODUCTION

It is necessary for Chinese firms to innovate by technology to catch-up their competitors in global competition. Many studies have analyzed late mover's advantage in technology innovation and its influence to the firm and industry in catching-up process (Shankar, Carpenter&Krishnamurthi, 1998; Lee, 2001; Huang, 2002). How to build the competitive advantage for the late mover through creative imitation, lower risk and lower cost of innovation compared to the first mover is always be focused. Our argument is that late mover's advantage is over stressed compare to the neglect of late mover's disadvantage in developing countries. As the latecomer in developing country, Chinese firms are confronted dual disadvantages. One is the common disadvantage confronted by followers in developed country, the other is the peculiar disadvantage faced by firms in developing country (Gao 2006). A key question for Chinese firms on innovation is how to choose a proper technology strategy to

utilize the advantage and to avoid disadvantage of latecomer.

This paper focuses on the impacts of technology strategy on the performance of innovation by comparatively analyzing the practices of three Chinese IC design firms. The research question is how technology strategy affects the outcome of technology innovation in developing country's firms to catch-up. It will be studied from four aspects, e.g. technology selection, technology opportunity, technology monopolization and necessary resources of technology innovation. The research results are expected to give some highlights on how Chinese firms acquire competitive advantage through technology innovation.

THEORETICAL BACKGROUND AND FRAMEWORK

A Review of the literature

The catching-up of developing countries has been paid more and more attention since 20'90s , From the perspective of national innovation system, Wong (1999) stated that the initial industrial condition has an important effect on the path choice of catching-up through analyzing the rapid caching-up process of semiconductor industry in Taiwan, Korea and Singapore. From the angle of technological regime, Breschi et al. (2000) presented that the technology regime will influence the technology catching-up of industries in developing countries, and measured the technology regime through many factors such as technology opportunity, rationality of innovation and the accumulation of technology. Through the case study of Korea, Lee and Lim (2001) concluded that the catching-up is easier to achieve in the regime that technology innovation occur frequently and is foreseeable. From the perspective of international innovation diffusion, Perez and Soete (1988) presented that sectors in developing countries that want to achieve technological catching-up through innovation, not only bear the fixed costs of innovation, but also pay the other costs to gain the resources required by catching-up, such as knowledge of science and technology relevant to innovation, experience on organizing, managing and marketing of innovation. They also presented that the opportunity for follower catching-up occurs in the period of technology paradigm transition. These literatures analyzed the catching-up from the industry level. A sector or an industry was looked as the research object and the black-box of firm's catching-up was not opened. Although many meaningful conclusions have been made, the theories can not explain the different technology innovation performance among firms in the same catching-up industry. To make up the shortage of studies mentioned above, some research is done from the micro-level. Lu and Mu （2003）had studied the indigenous innovation, capability development and competitive advantage in Chinese VCD industry, and presented that the innovation based on the characteristics of local demand is a necessary path for Chinese firms achieving technology catching-up. Gao (2005) pointed that emerging technologies supply an opportunity for developing countries to develop core technology with intellectual property right (IPR) and to catch-up. Gao presented the choice of technology area is very important to overcome the disadvantages of latecomer by analyzing the difficulties faced by Chinese firms in innovation independently. Wang and Yin (2007) apply the theory of emerging technology management to

analyze the innovation of Chinese firms. The study gave some suggestions to policy maker from the perspectives of industry environment and the evolution of technology strategy.

Theoretical Framework

Previous studies about catching-up on both levels have important light not only on the further research but also on the innovation practice of firms. But one question is how the industry-level factors such as technology regime affect the micro-level outcome such as technology innovation. Our arguments are that firm's technology strategy is an important mediating variable. It constructs the link between firms behavior and industry background. Based on this logic, this paper designs the theoretical framework as Figure1:

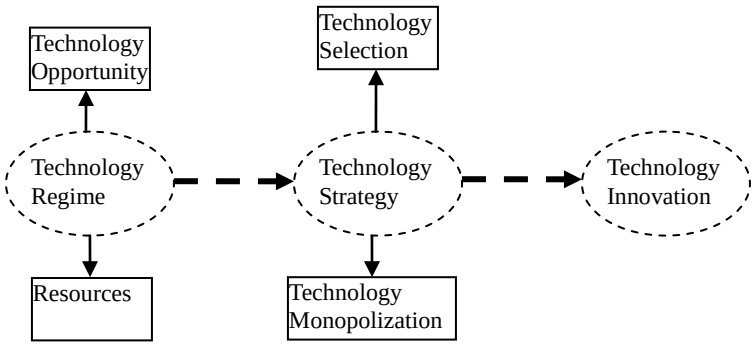

Figure 1: Theoretical Framework.

Extending the previous work (Breschi et al., 2001), technology regime includes two components, one is technology opportunity, refers to the possibility of realizing technology innovation (Lu & Yin 2006), the other is resources for the technology innovation. Perez and Soete (1988) presented that enterprises in developing countries intending to achieve technological catching-up through innovation, not only need the resources of hardware such as devices, but also need other resources including: 1) The resources to fill the gap between the internal knowledge and the knowledge required by the innovation; 2) To innovate successfully, the firm need to get the experiences and skills in organization, management and marketing; 3) It is necessary for firm to create an optimal external environment for successful innovation. The more advancement and newness of technology is and the more competition there is, the more resources are required. Additionally, the success of innovation is directly affected by the matching degree between the resources required by innovation and the operation capability of the firm. Technology strategy is measured by two constructs, one is technology selection, and the other is technology monopolization. Technology selection is one main component of technology strategy, and is the important premise to get the competition advantages of technology (Burgelman et al. 2004). The decision of technology selection will lead the different outcome of innovation and competition. Technology monopolization refers to the extent that the potential economic benefits of technology innovation monopolized by the firms developing the new technology (Day et al. 2000). When technology monopolization is in a high level, the firm will profit from the innovation. While technology monopolization is in a low level, the benefits of innovation will be minimized. The means to protect the technology monopolization include IPR, technology

confidentiality control, complementary assets management and lead time. (Day et al. 2000).

DATA AND METHOD

The reasons to choose IC design firms as sample are below. First, IC design is the most knowledge and intelligence intensive segment in IC industry. It also is the weakest one in Chinese IC industry. Due to the government initiatives and strong demand, Chinese IC design industry has had remarkable growth. From 243 companies in 2001, the industry grew to 450 companies in 2006 (Wang & Yin 2007).Despite the rapid growth, Chinese IC design firms face many problems comparing to oversea advanced firms. These problems include the low technological capability, small scale, lack of capital and IPR issue. Furthermore, Chinese IC design firms have to be confronted with the blockage to technology import. For instance, the sales of IC designed by Chinese firms only account for 8‰ of the world's total sales[1]. The core components still depend on import and the products mainly focus on the middle- and low-end market. These problems in IC design industry will restrict the further development of Chinese electronic and information industry. Therefore, it is significant for the development of Chinese electronic and information industry through studying on how IC design firms carry out technology innovation to acquire completive advantage.

This paper employs the case study method. There are four reasons to adopt the research method. Firstly, the developing history of Chinese IC design industry is short and turbulence. It is difficult to get the long-period and sequential data. Secondly, with highly creative and competitive in IC Design industry, the public data about technology innovation of the industry is very scarcity. Thirdly, because most of IC deign firms in China are start-ups and very small firms, the statistical data is very incomplete. Lastly, the case study is used for the explorative purpose. Based on the observation to the industry, the case study is suitable as the IC design firms in China can be classified into several types. Moreover, this paper comparatively studies three cases to enhance the reliability in order to overcome the unilateralism of single case.

The data in the research is mainly gathered by in-depth interview. The interviewees include the CEO, general management, the manager of R&D department and marketing department. The general information of firm and industry is collected by second-hand data such as industry database, electronic industrial journal and files of the firms. To guarantee the veracity of interview materials (Yin 2004), two interviewers were involved in the interviews. The interview material was processed by two interviewers respectively, and integrated later for further analysis.

THE CASE STUDY

IG Firm

[1] Resources from: A Global Sources, Special Issue for Electronic Engineering and China Semiconductor Industry Association, and is quoted by Sun C. X., www.esmchina.com/ART.8800068358_617671_c3df762e200605.HTM.

IG is a fabless design firm established in 2004. The founder of IG is a returnee from Singapore who owns the IPR of core technology of the firm. The firm is mainly engaged in the Intellectual Property (IP) core and Systems on a Chip (SOC） platform design and franchising. Its customers are mainly located in mainland China, Taiwan, Hong Kong and Korea. There are over 100 employees in this company. 90 employees are responsible for research and development (R&D) who working in the branch office located in Chengdu. 10 employees are responsible for marketing who are located in the branch office in Shenzhen. The first core technology is USB with the IPR by the founder. With the development of the firm, the entrepreneur realized that the rapid development of consumer electronic product would produce large scale demand for the audio coding and decoding technology. So the firm engaged into the product development of audio coder and decoder. With the rapid growth and development of the firm, the capabilities of technology innovation are improved continuously in the process of exploring new products. Up to 2008, the company could provide the design and development service for 13 types of the products. The market share accounts for 70% in domestic market segment. The products designed by IG began to be sold to Taiwan, Hong Kong, Europe and America. IG had mastered the core technology of USB2.0 PHY completely, and is the sole firm which has the ability to design the USB2.0 PHY IP in China. It is able to develop a series of USB IP with the world's leading technology in a short time. The sales revenue of the company was about CNY (Chinese currency) 100, 000 in 2004, but in 2007 its sales revenue exceeds CNY 20 million with an average annual growth rate as high as 300%. At present, the enterprise's investment of R&D account for 70-80% of the revenue, and the strong R&D supports the high-speed development of firm. In order to keep the technological advantage and lead the direction of technology innovation, IG has introduced some technical experts which have expertise required by the expanding of strategic business scope.

HW Firm

HW was established in 2005. It is a wholly owned subsidiary of a well-known Chinese home-appliance enterprises CH group. HW plays the role as IC design department of the group. The employees of HW are over 90 people, including over 10 management and administrative staff, 80 R&D staff. The establishment of HW was a strategic action for CH group to implement its strategic transition. Like most Chinese electronic makers, CH group is located in the end of the value chain, as it does not master the core technologies to manufacture a television. Especially in the fierce competition in the new business area of flat panel television, CH has to depend on imports to acquire the two core components - the core IC chips and PDP display. With the international competitive environment deteriorating, CH group decided to expand its business to the upstream of the value chain based on the long-term strategic plan. It focused on the independent innovation in the two technology field of IC chips and PDP display. This decision is support by the Ministry of Science and Technology of China, and two key projects were granted to support the independent innovation of CH. To achieve the strategic transition, CH adjusted its organization structure to set up two wholly owned subsidiary companies. One of them is HW to mainly focus on the video technology chip design and to develop the SOC design capability. The other is HS to mainly focus on the development of PDP display.

With relatively poor technical skills and talents, HW started SOC design from scratch. To fill the gap to the leading technology, the firm employed three engineers from USA. One of them works as the general manager of the firm. Furthermore, a large number of engineers were recruited to devote in the R&D. However, due to the mobility and a lack of experienced experts in IC design, the R&D works is in a slow process. As the strategic goal of HW is to supply the technological support to the transition of CH group, the R&D of HW had been focused on the basic technology with no clear target product since 2005. The R&D tasks were to accumulate technological capability and talents for CH group. In 2008, HW finished its first research mission. It started the first step of technology commercialization, although there is a long way to go for commercial purposes.

NSBIC Firm

NSBIC was established in June 2002 and mainly engaged in super large-scale integrated circuit (SLSI) design and sale service initially. Some entrepreneurs comprise the returnees from Silicon Valley who had rich chip design experience on data communication and the network security, and the others senior engineers came from famous Chinese IC corporations. NSBIC was an IC design fabless and a representative to the early pattern of Chinese IC design industry. Like other firms created by returnees, NSBIC has strong technological capability, and understand well the operation model abroad especially the model in Silicon Valley. However, it had to be subject to the localization in order to understand the domestic market and business environment in China. NSBIC selected the data communication (routers, switches) and information security as a strategic direction initially. It successfully developed a high performance exchange routing chip with own IPR. Although the technology was highly appreciated and supported by the state and local government on taxation, land preferential policies and technology projects, NSBIC encountered great difficulties in the process of technology commercialization because of tough competitor and the imperfect industrial environment. Later on, the firm won a domestic niche market by successfully developing a series of chips integrated data communication and information security with IPR. However, the revenue situation of the firm was worsening due to the strong challenges from the international competitor again. Facing the cut-throat competition, the top management team diverged from the strategic position. In 2007, great changes happened in the top management team. After the change, the firm adjusted its strategy to select the consumer electronic products as the further developing emphasis.

CASE COMAPARATIVE ANALYSIS

Technology selection

Based on its IP and technology advantage, IG firm comparatively analyzed the technology and market characteristics between high-end market such as Europe, USA and the low-end market in developing countries. Finally, IG firm selected the technological area which was ignored by foreign big companies but with high potential to grow up rapidly as the breakthrough. Avoiding competing with strong competitors in the early stage of development, IG reduced the uncertainty of technological innovation. In addition, as the degree of specialization and the

number of firms in IC design industry increased, IG firm gave up the design service in chips and systematic solution for customer. It fully concentrated on the development of own IP core. The operations not only distinguished itself from most of domestic IC design firm in business model, but also took the opportunity of the industrial specialization. IG firm became the largest IP core supplier in the similar products by franchising customers (IC design firms) to use its IP core in chip design.

Being the wholly owned subsidiary of CH group, the current technology strategy of HW firm is determined by the holistic technological strategy of the group. It severed the innovation strategy of CH. Flat panel television is going to be the strategic business of CH, but the key technologies are totally depend on the import. To fulfill the target of transition, CH needs to have the core technological capability on SOC design of audio and video in the future strategic business field. Hence, the mission of HW in the initial stage is to accumulate the SOC design capability and supply the technologies innovated by itself to support the strategic transition of CH.

NSBIC is the only firm in the cases selected the data communication and information security instead of consumer electronics as the initial breakthrough that required more advanced technological capability. The core technology in data communication and information security field was grasped by leading firms in USA and Europe. The core chips in this field needed by domestic integrated system manufactures were totally imported. The reasons why NSBIC selected this field were as follows: firstly, the key founder of NSBIC is of high expertise in this field; secondly, this field was inspired greatly by the government. The result of the selection is that NSBIC had to directly compete with the strong leading firms in high technological level. Although the chips designed by NSBIC achieved the world leading level, it suffered huge difficulties in the commercialization of technology.

Technology Opportunity

Although all the three case firms are IC design firms, they are involved in different technology field. Therefore, their technology opportunities are different. The following part will evaluate the technology opportunity of the case firms from two criteria. One is the technology superiority and scientificity. The other is the degree to meet the market demand (Lu & Yin 2006).

IG is mainly engaged in the IP core and SOC platform design and franchising. With the future development of IC industry, the rapid demand changing will require specialization in professional divisions. It is an inevitable tendency to use IP core in SOC platform design in order to improve the efficiency of design service. In the relatively mature area with high technological level such as PC and network communication, foreign firms have accumulated strong capability in IP core development to get competitive advantage. Whereas, in the emerging consumer electronic field, the design service of IP core and SOC just started in international and indigenous firms. Therefore, there are more possibilities that IG selected the business area to make innovation. With the increased number of IC design firms in consumer electronic industry,

the demand to the IP core and SOC platform will grow up rapidly. Thereby, the strategic position of IG gets a good chance to innovation from the perspective of market demand.

In the digital audio coding and decoding technology field, although the foreign firms have not the absolute technology advantage, the competition is still rather fierce because most of the IC design firms in Taiwan, Hong Kong and mainland China invest in this area. From the first criteria of technology superiority and scientificity, HW has not the leading technology capability in this field. The technology is gained by talents recruitment and R&D cooperation. There is big uncertainty in the technology superiority. However, CH is the direct big consumer, all of HW technology products have the priority to be applied to the product lines of CH. In this sense, HW has a better opportunity from the perspective of market demand.

From the criteria of technology superiority and scientificity, the product developed by NSBIC independently has excellent performance, and get a good opportunity to innovate successfully. However, from the criteria of market demand, the NSBIC's product did not consider the characteristics of downstream users' needs. It only supplied the core chips to users instead of the entire system solution. It failed to satisfy the requirement of integration so that it had difficulties in marketing. In this case, the technology opportunity of the company was reduced.

Table 1: Comparative Analysis on the Technology Opportunity in Three Firms.

Item / Firm	**Technology superiority and scientificity**	**Market demand**	**Technology opportunity**
IG	Middle	High	High
HW	Lower	High	Middle
NSBIC	High	Lowest	Lower

Technology Monopolization

In IC design industry, except the firms providing the reusable IP core use patens to protect their innovation, most of the firms in chips design control the confidentiality of the technology to protect their innovation. In the following part, the authors will analyze the characteristics of technology monopolization in the three case firms.
IG is the reusable IP core provider. It profits from the innovation by technology franchising and technology transfer. Thus, IPR is a proper means to protect the technology monopolization. In addition, the case study finds that IG increased the possibility to get the complementary assets through maintain a constructive and collaborative relationship with foundries (the IC chips manufacturers) in order to accelerate the commercialization of its innovation.

HW devoted into is an emerging industry with tough competition. HW does not have superior technology advantage on the core technological capability. In this case, its innovation is easily imitated. HW firm protected its innovation by technology confidentiality control. Due to the relationship with CH group, HW can easily get the complementary assets and technology from

its parent company. The speed to launch the new product is rapid, because its product can be verified more quickly than other homogeneous firms.

Comparing to IG and HW, the technology monopolization of NSBIC was decreased by the following reasons. First, NSBIC committed to a high-end technology field. The competitors were world leading firms in the business area such as Broadcom. Although NSBIC successfully developed and patented the leading product with high performance in a short time, it exposed the strategic intentions too early because of over publicity. The competitors quickly developed the similar product through bypassing the patent barriers. At the same time, the competitors set difficulties in marketing activities of NSBIC by adroit operational skills. Second, from the perspective of technical system, the core chips designed by NSBIC need a series of complementary technology and assets to fulfill its systematic solutions. As a start-up, the managers of NSBIC did not well understand the domestic industry environment. It led the difficulties to get the complementary technology and assets.

Table 2: Comparative Analysis on the Technology Monopolization in Three firms.

Item / Firm	IPR	Technology confidentiality	Complementary Assets	Lead Time	Technology Monopolization
IG	●		High	●	High
HW		●	High	●	Middle
NSBIC	●		Low		Low

Resources for Technological Innovation

In the consumer electronic business area, IG firm has no strong international competitor. The barriers of innovate was relatively low. It is a key factor for the success of IP supplier to keep cooperation with foundry. The direct customers of IG are firms which design consumer electronic chips and system solutions. It is very important to consider the requirement of downstream users in the design process. IG used different channels to acquire the resources required by innovation. First, with the development from single product to diversity products, IG had accumulated its technological capability, especially some important know-how. To expand its business, IG kept recruiting the senior technical personnel from some developed countries to guarantee the dynamic accumulation of technological capability. Second, IG set up a branch office in Shenzhen to ensure the fast response to the market through keeping a good relationship with key customers in a long term. Thirdly, by keeping a close relation with foundry which is difficult for other firms to imitate, IG improves the performance of product and shortens the testing time. Moreover, it can reach more client resources through the network of foundry. Finally, to enlarge the demand of IP core, IG cooperated with government and public media. It promoted domestic IC design firms to develop new chips more efficiently by using IP core.

Although the technology entry barrier of HW is low, the firm itself has weak technology capability. Comparing to domestic IC design firms developing similar products, of HW has the advantages to get necessary resources for innovation. First, HW was strongly supported by its

parent company on financial aspect. Moreover, its market position was very clear, so the competition pressure is relatively low. Second, HW was easier to access to the complementary resources for technical testing, because its product was applied to the product lines of CH group. Third, being the wholly owned subsidiary of CH group, HW can share the strong social capital with it parent company to get the external resources required by innovation. On the other hand, HW had to face some disadvantages because of its special situation. First, talents introduction is the main channel to accumulate technological capability, but because the CH is a state-owned enterprise, HW faced some mechanism obstacles to appeal talents. Second, the technology strategy of HW is determined by CH strategy. The firm can not adjust its technology to responses to the market needs. The situation leads to a result that the resources are not efficiently utilized. Although HW can improve the bargain ability of CH with foreign IC suppliers, it is not helpful for HW to strengthen the core competence because it lacks of the experience in management and marketing for further innovation.

NSBIC involved in the business area with high level of entry barrier, but the competitors are very strong with monopoly. In this sense, the innovation of NSBIC required more resources. Based on the views of Perez and Soete (1988), the failure of NSBIC can be explained by the lack of two resources. One is the resource shortage of the experiences on management and marketing. The firm copied the business model in Silicon-Valley initially. All the resources are invested in R&D activities. The resources for localization are very short. The other is the resource shortage on social capital. Although NSBIC got many encouragement and rewards from government, it is a lack of the social capital to realize technology commercialization. NSBIC had to provide the complementary technology and assets by consuming the scarce internal resources, because it could not get these resources from other firms. The risks of innovation are increased by the above reasons.

CONCLUSIONS AND POLICY SUGGESTIONS

Through comparative analysis of the three cases, the paper makes the below conclusions.

First, technological catching-up theory holds that the conversion of technology paradigms can provide an opportunity of technology catching-up for latecomers. However, through the case study we found that the opportunity window of latecomers firms can be opened not only in the conversion period of technology paradigms, but also in the conversion period of technology applications. The latter is more meaningful to independent innovation of Chinese enterprises. In reality, a number of key technology areas (such as IC) are not yet in the period of technology paradigm shift, but these areas have strategic impact on the upgrading of national industrial structure. The Chinese firms cannot wait for the arrival of technology paradigms conversion and then to innovate. In these technology areas, demand is increasingly becoming the main driving force of technological innovation. In other words, the firms have the advantage of innovation who can find firstly new applications of existing technology. The vast and diversification of market demand of China provide good opportunity of "trial and error" and the accumulation of technology capabilities for such innovation. It will act as an opportunity for technology catching-up.

Second, when Chinese enterprises select the technology areas of innovation, they should not only consider the technology capabilities and accumulation degree of the enterprises, but even more analyze the amount and their availability of necessary resources for successful innovation. To the large numbers of start-up enterprises with limited resources, it is reasonable to select the technology that close to the market needs and with short innovative cycle. An obvious example is the enterprises with comparatively good profitability all choose consumer electronics as their core technology areas in domestic IC design field. Although there are a number of leading IC design enterprises committed to the development of TD-SCDMA series product, the necessary resources of successful innovation cannot be afforded on their own. Although strong support is from government, it is still very difficult to reduce the tremendous uncertainty the firms facing.

Third, for Chinese enterprises (especially IC enterprises), once a reasonable technology area is chosen, the main difficulties affecting innovation is a lack of operational capacity rather than the lack of technology capacity. It leads to the lack of experience in marketing, management and channels access to complementary assets required by innovation.

Fourth, technology innovation of Chinese enterprises not only faces the common disadvantages of "late comer", but also faces the following disadvantages that are specific for innovation in under-developed countries. First, the enterprises of under-developed countries are always far away from the leading technology source, which limited the opportunity of achieving technology overtaking in the leading technology areas. Secondly, the enterprises of under-developed countries are always far away from the users of leading technology, which limited the commercialization experience of leading technology. Thirdly, it is a particular disadvantage that there is a lack of specialized technology, human resources, infrastructure and common technology in realizing technological overtaking. In our case study, many managers in IC design enterprises said that the lack of professional and technical personnel (especially in the high- and middle-level), professional design tools and software platforms are critical obstacles in the process of transferring to high-end products.
Finally, Chinese enterprises in the period of technology catching-up must make a tradeoff to design the strategy management tools, such as patent, confidentiality and complementary asset management, so that they can ensure obtaining the competitive advantage and financial benefits of technology innovation.

Based on the conclusions, this paper proposes the following policy recommendations, in order to more effectively promote technology innovation of Chinese IC design enterprises and achieve technology catching up.

Firms in IC design industry are mainly SMEs at present. Although the high flexibility of these enterprises is beneficial to achieving the technology catching up by disruptive strategy, the unfavorable position as latecomers may hamper the development and growth of the enterprises. Therefore, the government should learn the catching-up experiences of “Innovation Network of SMEs "in Taiwan. On the one hand, the government should accelerate the construction of

infrastructure and public technology platform, so as to provide specialized technology and equipment resources for SMEs and make up "latecomer disadvantage"; On the other hand, the government should actively guide and encourage enterprises to establish innovation networks in order to provide adequate external resources for innovation. At the same time, research institutions should be encouraged to conduct R&D on advanced technology with enterprises, so as to make up the shortage of enterprise technology source.

The professionals should be introduced and educated actively in IC design industry. The lack of high- and middle-level professional and market experience are two major bottlenecks to limit the innovation in domestic IC design enterprises. Currently, many high-level IC design talents in developed countries are Chinese, including personnel studying abroad. Government should design various systems and policies to attract overseas Chinese as entrepreneurs or employees in China. It will effectively solve the shortage of professionals in domestic IC design industry. In order to compensate for the lack of market experience, the Chinese firms cannot only transplant the foreign operation model. It is necessary to localize operation model based on understanding the advantages and disadvantages of local enterprises independent innovation. Government should establish platform to provide innovative experience exchange and training for SMES, thereby reducing the cost of "trial and error".

LIMITATION AND FURTHER RESEARCH

This study extends the previous research on the catching-up in developing country. The theories built on the industry-level are linked with the firms' strategic behavior in the micro-level through comparative analysis among three cases in Chinese IC design industry. This paper has some limitations as followes: 1) Due to the complexity of Cross-Level study, the research framework is not complete and perfect. For example, in our framework, technology regime affects the technology strategy by technology opportunity and innovation resources in one way. In fact, the technology strategy based on the capability of firm may has effect on the technology opportunity identification and on the acquisition of resources. To reduce the confusion and complexity, this paper only analyzed the main effect in one direction;2) Three cases are all from IC design industry, so the second research limitation is the replication logic. The case study can be questioned as a contingency instance. Can the case be duplicated in any other industry context? These are questions can be further studied in the technology innovation in the context of catching-up in developing countries.

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WHAT SHOULD BE DONE FOR IMPROVING EMPLOYEE TRAINING PERFORMANCE? A HUMAN RESOURCE DEVELOPMENT PERSPECTIVE

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ABSTRACT

Training plays a crucial role in organizational employment. The enterprise must achieve sustainable competitive advantage by efficiently training its employees. Promoting the training satisfaction and consequently the training efficiency stands as a significant issue for the training unit. The service industries, among all the industries, reinforce the training satisfaction. Thus the industries cannot deny the importance of the trainer-trainee fit as the major contribution to training efficiency.

This research, making use of SPSS 12.0, analyzes the trainer-trainee fits as the influences on training satisfaction. The results, under the securitization of Regression Analysis and Independent Sample T Test, and One Way Analysis of Variance, show that supplementary fit has positive relation with training satisfaction. The trainer-trainee communication grows with their good interactions that would further promote the knowledge transferring. In the end, the trainee's satisfaction with the training will be increased and contribute to the expected efficiency. Furthermore, the supplementary fit for educational background has greater influence than complimentary fit on training satisfaction.

Keywords: Training Development, Trainer-Trainee Relationship, Trainer-Trainee Fit, Training Effectiveness

INTRODUCTION

Training is one of the most important strategies for organizations to help employees gain proper knowledge and skills needed to meet the environment challenges (Chuang, Liao and Tai, 2005; Goldstein and Gilliam, 1990; Rosow and Zager, 1988). Therefore, training plays a crucial role in organizational employment. The enterprise achieves sustainable competitive advantage by efficiently training its employees. While training changes workers by teaching them the working skills, the ultimate goal of training is to improve the employees' abilities in solving the organizational problems. Training is laden with issues regarding its contribution

to organizational value and employee effectiveness (Patrick and Owens, 2006). Therefore, the efficiency of training is more important than its process. In addition, the trainee's satisfaction with the training, which has been a significant scale index (Kirkpatrick, 1979) and becoming a major part of training efficiency (Carnevale and Schulz, 1990), includes the trainee's intimacy with and feeling about the trainer.

As a result, understanding the trainee's satisfaction as a way to achieve the training efficiency will be a great contribution to the competition of an enterprise. Past studies have examined training and its relationship with such factors as satisfaction, trust, and commitment (Korsgaard, Roberson, and Rymph, 1998; Skarlicki and Latham, 1997; Taylor, Masterson, Renard, and Tracy, 1998). However, improving training effectiveness by measuring training's effect on employee' training satisfaction has not often been context.

Chuang, Liao and Tai (2005) purpose that part of the training success hinges on trainee' learning, and meta-analysis reviews also confirmed that learning could influence trainees' transfer outcome (Alliger et al, 1997; Cheng and Ho, 2001). Moreover, training motivation can be described as a specific desire on the part of the trainee to learn the content of the training program (Noe and Schmitt, 1986), which is also likely to have a direct impact on training outcomes (Colquitt, LePine, and Noe, 2000; Martocchio and Webster, 1992; Mathieu, Tannenbaum, and Salas, 1992; Noe, 1986; Quińones, 1995). Motivation to learn among trainees can be enhanced and training outcomes will be increased (Liao and Tai, 2006; Colquitt et al., 2000; Korsgaard et al, 1998). Therefore, to improve the motivation to learn of the trainee and thus the training satisfaction and training efficiency becomes the important issue for training program.

Academic literature features that the trainer could greatly affect the training satisfaction and the consequent training efficiency (Bushnell, 1990; McDermott, 1987). Analoui (1994) also considers that the trainer, as the key transmitter of an amateur trainee to a mature employee, stands as the chief contributing cause for a successful training. The trainer serves the example for the trainees' behaviors within an organization and gives them positive attitude of working (Pettigrew, 1979). Furthermore, the trainer is also the conveyer of knowledge. The relationship between the trainer and the trainee influences the teaching of the former and the learning of the later. Such a situation indicates that the trainer is not only the central figure for the trainee's learning new abilities but also an important part of a successful training (Marx, 1986).

Many researchers point out that Teacher-Student relationship is positively relative to the effective studying (Freese, 1999; Zhuojun, 2000; Griffin, 2001; Klem and Connell, 2004).

Davis (2003) believes that a good teacher-student relationship makes a student active in studying. The students are confident of developing new abilities only when they feel being cared by the teacher. Therefore, good teacher-student relationship is helpful to the training efficiency (Murray and Greenberg, 2006). In addition, Hunt and Michael (1983) also state that the teacher-student relationship could inspire the working atmosphere, improve the intelligence of the workers, and decrease the staff turnover rate. Such a connection, therefore, as an important facility for the staff inside an organization, contributes a lot to the training and consequently the working efficiency.

The establishment of teacher-student relationship is partially founded on the similarities of the teacher and the student (Allen, Poteetm, and Burroughs, 1997). Jones (1989) believes that the student, feeling familiar with the one who educates him or her, might evaluate his or her teacher positively (have more satisfaction with his or her teacher). The student, according to Jones (1989), would consider such teach efficient. However, in the teacher-student relationship, the trainer-trainee relationship is also a significant concept. In the process of training, a trainee learns from the trainer the knowledge needed for the work. The learning relies heavily on the quality of the communication (Francis, 1995). In other words, if the trainer and the trainee may achieve in their fitness through their familiarity, which might contribute to the quality of communication and the student's satisfaction with the teacher, such a connection has great influence on an effective training.

"Fit" means the matching between people, emphasizing the similarity between two compared subjects. With such similarity, the two people may attract each other so as to achieve in good communication (Geddes and Konrad, 2003). Being similar, matching, and communicative, the two subjects would like, appreciate, and then have positive attitudes about each other (Jackson et al, 1991). Lankau and Riordan (2005) commented that the similarity and fitness within the teacher-student relationship might produce the inter-dependence. Such dependence would affect the two subjects' attractions to the other while the result in the improvement of the training connection. In addition, scholars also found that when the fitness between the employer and the employee works well in an organization, the employee is likely to identify him or herself with the actions of the employer and to work hard. The identification, therefore, is inclined to cause the satisfaction with the work (Tsui and O'Reilly, 1989).

Muchinsky and Monahan (1987) point out that there are two kinds of fit. The first one is "Supplementary Fit" emphasizing the sameness. People are inclined to attract one another with similarity; they would share values and socially interact with one another in positive ways (O'Reilly, Chatman, and Caldwell, 1991; Tsui and O'Reilly, 1989). The other one

emphasizes the compensation: the “Complementary Fit”. Such fit specifies that the differences among people, especially the ones on working techniques, might result in the positive relationship of two subjects within an organization (Dryer and Horowitz, 1997).

Some scholars point out that the “Supplementary Fit” (with the same backgrounds) is caused by the consensus and sympathy between two subjects within an organization. Those attitudes make the two people communicate and then cooperate with each other easily (Weldon and Weingart, 1993). There are also researchers with the points that “Complementary Fit” (with the different backgrounds) could inspire various ideas among the workers within an organization and consequently helps the working efficiency (Gladstein, 1984). Since the two kinds of fit positively assist the organization, which one of them might attain more importance to the organizational training by inspiring the trainee’s motivation to learn and his satisfaction with the training? This question has not been answered by the researchers of the past years and therefore stands as the theme of my research. The analysis within this research is to discover the connection between the trainer-trainee fit and the satisfaction with the training and to find the cause of this connection. The discoveries may be instrumental to the organizational managements for the trainings in academic units and enterprises in the future.

In addition, the training activities in human resource management contribute to the performances of small-and-medium businesses. The business, furthermore, evidently take training as the crucial means to improve skills, transform the attitudes, and update the ideas of management within the organization (Altinay, Altinay, and Gannon, 2008). The performances of organization serve as the determining factor of the economic development of a country (Soriano and Dobon, 2009). As a result, the analysis and discussion of the training in service industries deeply concerns the national economics. The findings of this research may be helpful for these analysis and discussion. The relationship between the trainer-trainee fit and the training satisfaction will provide an advantageous rationality for the businesses and academic researches. The purpose of this study is to provide the connection between the trainer-trainee fit and the satisfaction with the training and, moreover, to analyze trainer-trainee relationship as the influence on the satisfaction with the training.

THEORIES AND HYPOTHESES

The similarity-attraction theory suggests that the subjects within the same society are essentially similar to each other and are thus easier to establish intimacy. The intimate connection may provide for both sides the pleasure and positive attitudes to each other

(Byrne, 1971; Mark, Ellen, and Alana, 1988; Pfeffer, 1985; Jackson et al, 1991). Furthermore, if there is fit between the trainer and trainee, they could exchange the right information and result in the good communication and the increasing satisfaction with the training (Derosa et al, 2004). Therefore, this research holds the hypothesis that the trainer-trainee fit and the training efficiency are positively connected.

When there is the fit of values between two subjects, the communal attraction and closeness might increase (Byrne, Clore, and Worchel, 1966). The employer and employee establish similar perceptions because of the fit of values. The same usages of language, furthermore, will cause high-quality communication (Meglino, Ravlin, Adkins, 1989). The familiar behaviors and attitudes of dealing with works serve as the foundation of consensus. In addition, the fit of values will also make the subjects identify the others as the same kind of people as themselves, shortening the distance of both sides and producing trustiness and favor (Farh, Tsui, Xin, and Cheng, 1998).

According to the researches above stated, the fit of values between trainer and trainee cause the same logic in thinking about the works. In the training, the trainee may like the talking with the trainer because the former takes the later as the same kind of person and, not rejecting him or her, willingly receive the ideas of the later or the purpose of the training. The communal understanding on the basis of good interaction helps the social reliance, coming into the high satisfaction with the training. This study, therefore, presumes that the fit of the values between the trainer and the trainee can be positively connected with the satisfaction with the training:

Hypothesis 1: *The trainer-trainee fit will be positively related to training satisfaction.*

The research of Farh et al. (1998) consists of the discovery that the similar education of the employer and the employee is positively connected with the employer's evaluation of the employee's performance. Meanwhile, the members of an organization like to have the coworkers of the same characteristics. The inclination makes them choose their coworkers of such characteristics as graduating from the same university (Schneider, 1987). The subjects with the fits of education (or similar educational backgrounds), such as the same academic degree, the same university, or the same major, might have similar logics of thinking and therefore would not be frustrated in their communication. They are inclined to take each other as the insiders.

As a result, the people as "insiders" with similar educational backgrounds will provide each other the intimacy, confidence, comradeship, and eventually the fit. In the proceeding

training, when the trainer takes the trainee as the insider, the former will selflessly transmit the knowledge and techniques to the later, improving the efficiency of training. At the same time, when the trainee takes the trainer as the insider, the former will also willingly listen to the later, improving the satisfaction with the training.

However, according to the viewpoint of demand-supply, the fit of two subjects occurs when one's demand or personal desire are fulfilled by the other (Kristof, 1996). The supplementary fit in education might make the trainer and trainee share the different knowledge and techniques according to their different experiences, educations, or majors, because they, not understanding each other, would not come into competition and the conflicts of interests. Such a relationship of demand and supply might also be formed with the subjects' respect and admiration towards each other.

Therefore, if the trainer and trainee have supplementary fit in education, the trainer might supply the trainee with the knowledge or techniques the later lacks for working. When the training is satisfied with this supply, he or she is likely to be positively motivated. The respect and admiration that a trainee processes towards the trainer would also result in good communication and connection when the trainee is likely to humbly learn from the trainer. Furthermore, the discussion and sharing of different experience and knowledge would also produce the sense of achievement and the satisfaction with the learning. All those factors contribute to the satisfaction with the training.

The past researches and the discussions stated above reveal that both the supplementary and complementary fits in education for the trainer-trainee relationship will promote the satisfaction with the training. However, the past researches do not point out which kind of the fits works better. As discovered in this research, most trainings of the enterprises, as initial training or job training, are the short-term ones within 3 to 6 weeks, in which the trainers may not possible to develop good teacher-student relationship with the trainee. Furthermore, those trainers may come from the consulting company, academic or government units. The trainer and trainee do not know each other before the training and will just meet for a short time. There would be no close relationship, in other words. If, in this condition, the trainee identifies the trainer in the first impression, the relationship becomes better than the one in the demand-and-supply connection resulted from the sharing and discussion. The supplementary fit therefore works better than the complimentary one to improve the training satisfaction. This study thus holds the hypothesis that the supplementary fit in education has greater influence on the satisfaction with the training than the complimentary one.

Hypothesis 2: *In the trainer-trainee relationship, the influence of supplementary fit for educational background on training satisfaction will be greater than complimentary fit.*

METHODS

Sample and Data Collection Procedure

The questionnaires survey, with the advantages of low cost, carrying out easily, high reliability, and few frustrations in the operation, stands as the central method of this research. The samples of this research are the trainees in the trainings (like the ones for further education; for transferring the career; or for the commissions) held by *Department of Labor, Taipei City Government*. Focused on the list of the workers in service industries given by the official unit, the survey consists of the questionnaires of the random samples of trainees. In addition, there are also samples of the trainees in the training held by the enterprises, academic units and other administrations.

Before or right after the end of the trainings, the survey starts with the training assistants' distributions of questionnaires to the trainees in person or by mailing and then analyzes the trainees' reaction, learning, behavior, and results as the important standards for the training satisfaction. The assistants, or the employees who once participated in the trainings (before or on-service) recollected the questionnaires after the trainees complete filling. The period of questionnaires distribution starts on December 2, 2008 and ends on February 15, 2009. 826 questionnaires have been sent to the trainees and 535 copies have been recollected. The retrieve rate is 64.76%. After collation by ruling out the ones with incomplete or only-one answers, the invalid questionnaires are 138 copies and the valid ones are 397 copies. So the valid retrieve rate is 48.06%.

Variables Definition and Measures

Independent Variables

The "trainer-trainee fit" serves as the independent variable for this research. Taking Muchinsky and Monahan's points of "supplementary fit" and "complementary fit" (1987) as the overall range for the idea of fit, this research makes the chart for the "supplementary fit in values" with 19 articles. With Lakert's standards of "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree," the points are given from 1 to 5. The higher the points are, the trainer-trainee fit should be.

In the parts of supplementary and complimentary fits in education, this research compares the education backgrounds of the trainers and the trainees. If one description of education for both sides reveals the same, it is given the point "1". In contrast, if it reveals the difference, it will be given the point "2" as the complimentary fit in education.

Dependent Variables

The training satisfaction is the dependent variable for this research. According the four levels issued by Kirkpatrick, the trainees' reactions, learning, behaviors, and results are designed into the evaluation chart. The chart has 27 entries, including the design of curses, the inspiration in class, the way the trainers carry out his or her teaching, the trainer-trainee interactions, the improvements of the trainees' professional knowledge, negotiation ability, and working attitudes, etc. With Lakert's standards of "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree," the points are given from 1 to 5. The higher the points are, the training satisfaction should be.

Analysis Methods

The first step is to rule out the invalid questionnaires with incomplete answers. The second step is to code the data into computer files. And then SPSS 12.0 is used to analyze the codes into the statistics. The data analysis method includes: Reliability, validity analysis, description covariance analysis, Pearson's correlation, one way ANOVA, Regression Analysis, and Independent Sample T test.

RESULTS

Validity and Reliability

To hold Content Validity, the questions of the questionnaire in this research are mainly of professional predictive validity. They are composed of the opinions of the experts in the field and critically scrutinized in the procedure of composition, and are thus qualified to be the representatives for the studied issue. In addition to the researches in the past years, the scholars' professional advices are also necessary for the examination of the title and the questions as the expressive ideas to the questioned trainees. The final version of the questionnaire, therefore, with the professional helps, processes high predictive validity.

To construct Validity, this research makes use of Principle Component Analysis so as to find the Common Factor. The principle of selecting the characteristic root greater than 1, as

stated by Kaiser (1960), is accompanied with the corrected item-total loading to examine the relativities of each question. The factor loading is used to examine the proceeding questioning so as to decide whether one question should be ruled out or kept in the questionnaire. The variables are used to sieve the validity of the questionnaire. Finally, in this research I decide to rule out the relativity lower than 0.4 and the weight lesser than 0.6. The independent variables (supplementary fit of values) ruled out 2 of the 19 questions and the dependable variables ruled out one of the 27 questions.

As for the reliability, this research takes Cronbach's α coefficient to evaluate the degree of consistency under aspects. The chart with the coefficient over 0.90 processes high reliability. The complimentary fit in values in this research, with its 17 articles, gives the Cronbach's α result as 0.923. The training satisfaction, with its 19 articles, gives the Cronbach's α as 0.96. Both results are highly reliable.

Correlation Analyses

In this research, the variables of the supplementary fit and the dependent variables of the complimentary fit are both of continuous variables. Thus one of Pearson's Correlations, Pearson product-moment correlation, is here used to analyze the relation of the two variables as the indexes of continuous variables. These indexes are used to analyze coefficients of these two variables and p-value is used to examine the coefficients' significance. The correlation, between the independent variables (supplementary fit) and the dependent variables (training satisfaction) is 0.542, and the p-value is less then 0.01, indicating the positive relation.

The Relationship between Supplementary Fit and the Training Satisfaction

The simple regression is used to test the influence of the supplementary fit on the training satisfaction. Table 1 show that the regression analysis reveals that β is 0.576 (t=12,817, p=0.000), suggesting that the higher the supplementary fit in values between the trainer and trainee is, the better the training satisfaction is.

Table 1: Relationship between supplementary fit and the Training Satisfaction.

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	β	Std. Error	β Distribution		
Constant	1.617	0.183		8.852	0.000(**)
Supplementary Fit in Values	0.576	0.045	0.542	12.817	0.000(**)

** indicates 0.01 level of significance

The Relationship between Supplementary and Complimentary Fits in Education and the Training Satisfaction

The independent sample T test is used to examine the influences of both fits in education. As revealed in Table 2, the result shows that the equality of variables through Levene test is 0.087<0.15 (t=0.015), indicating that the variances are significantly different from each other and that the supplementary and complimentary fits between trainers and trainees have significant influence on training satisfaction.

Table 2: Relationship between Supplementary and Complimentary Fits in Education and the Training Satisfaction.

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	T	Std. Error
Equal variances assumed	2.941	0.087*	2.339	0.020
Equal variances not assumed			2.456	0.015*

* indicates 0.05 level of significance

In addition, the average quantity is further used to test the degree of influence by the supplementary and complementary fits for education on training satisfaction. As shown in Table 3, the result shows that the mean of supplementary fit is 4.0271 greater than complementary fit which is equal to 3.8855, suggesting that the supplementary fit in education has greater influence on training satisfaction than the complimentary fit.

Table 3: Comparison of Average Quantities of Supplementary and Complementary Fits.

	N	Mean	Std. Deveiation	Std. Error Mean
Supplementary Fit in Education	146	4.0271	0.51284	0.04244
Complimentary Fit in Education	251	3.8855	0.61811	0.03902

The Relationship between Demographic Background and Training Satisfaction

For the further understanding of the difference the trainer and trainee within an organization as the influence on the training satisfaction, this research takes the single-reason variables for analysis. As shown in Table 4, the result shows that P=0.644>0.1, indicating that there is no obvious influence of the trainers' positions on the training satisfaction. In other words, wherever the trainer comes from, there will be no influence on the fit and thus no visible consequence on the training satisfaction.

Table 4: Relationship between the Trainer's Organizational Position and Training Satisfaction.

	Sum of Squares	Mean Square	F	Sig.
Between Group	71.967	1.124	0.922	0.644
Within Group	404.733	1.219		
Total	476.700			

Furthermore, this research tries to figure out the sex difference as the influence on the training satisfaction. Therefore, with the independent sample T test as the examination for the relationship between the sex difference and training satisfaction, the result (as in Table 5) shows that the of Levene test is 0.455>0.15 (t=0.935), indicating that the variables have no apparent difference. In other words, the sex distinction of the trainer and trainee does not stand as an influence on trainer-trainee fit and consequently on training satisfaction.

Table 5: Relationship between the Sex Difference within trainer-trainee relationship and Training Satisfaction.

	Levene's Test for Equality of Variances		t-test for Equality of Means	
	F	Sig.	T	Std. Error
Equal variances assumed	0.558	0.455	0.082	0.935
Equal variances not assumed			0.082	0.935

DISCUSSION

This study discovers that the higher the supplementary fit in values is, the better the training satisfaction is. The training will thus be supported. The sharing of values makes both the trainer and trainee thinks in the similar logic and then mutually communicative. The trainee, not rejecting such a person, will thus regard the trainer as the insider and willingly receive the order and purpose of the training. The good communication and positive social interaction within the training will therefore result in the high satisfaction.

One of the results in this research shows that, for educational background, the

supplementary fit has greater influence on the training satisfaction than complimentary fit. The supplementary fit makes both the trainer and trainee think of each other as insiders and therefore feel the intimacy in the training activities. The trainer will also take the trainee as the insider and selflessly deliver his or her knowledge to the trainee. The selflessness shortens the time of learning and increase the training efficiency. Meanwhile, when the trainee takes the trainer as the insider, the former will be more obedient and thus have more satisfaction with the training.

When the training unit is choosing the trainer, it will consider the various resources like the consultant company, the academic unit, the government unit, the original company (that holds the training), or other companies within the same industry. The result of this research shows that the trainer's organizational position does not affect the trainer-trainee fit and thus has little influence on the training satisfaction. The discovery suggests that the comradeship of being in the same company does not make the trainee feel more satisfied with the training. Similarly, the trainee will not take the trainer as a more professional lecturer even if the trainer comes from the academic unit or consulting company.

The stereotypical conception of sex difference consists of the idea that the people of different sexes might attract each other. However, it is still possible that the people with the same sex might get along with each other easily. As discovered in this research, the sex difference does not influence the trainer-trainee fit and has little effect on the training satisfaction. The discovery suggests that sex difference perhaps affects social relationships, but it does not stand as the key for the trainee's motive of learning. Confronting the trainer of the same or different sex, the trainee will not adjust his or her satisfaction with training.

CONTRIBUTION

Some scholars state that supplementary fit (the same backgrounds) makes the trainer and the trainee think and deal with things in the same way and thus makes them communicative (Weldon and Weigart, 1993). There are also scholars believe that the complimentary fit (different backgrounds) might inspire the members' different thoughts and thus achieve in the efficient working (Gladstein, 1984). However, the researches of the past years, focused on the positive influences of both supplementary and complimentary fits on the organizational training, do not include the comparison of the two kinds of fit so as to figure out which of them is the most important. Which kind of fit might work better to motivate the trainees' learning and increase the satisfaction with the training? This is the question this research tries to answer.

As the result shows, the higher the fit in values is, the better the satisfaction is. In addition, the supplementary fit has greater influence than the complementary fit, meaning that the background of sameness will make the trainer and trainee talk about the same topic either in training or in the private. The good communication brings good transmission of knowledge. The trainee's satisfaction with the trainee, therefore, will show the expected achievement. However, one of the reasons why the supplementary fits of education within trainer-trainee relationship are greater than complimentary fit is that this research is focused on the service industries in which the social relationship must be reinforced more than that in other industries. The employees, therefore, are inclined to think highly of the intimacy in the trainings. When the intimacy is good, so will be the interaction within the training and the training satisfaction. The different educations and the acquiring of new knowledge thus do not stand as the important factors for the training satisfaction.

Furthermore, this research also shows that the trainee with a under graduate degree present higher motive to be involved in the activities of the training. However, because of the problems of family and physical strength, the trainees after the middle age show lower motives in training. Meanwhile, the organization that holds the training has no inclination of selecting the trainer of some particular age or sex. However, the trainers of high education, like from graduate schools, serve as the good choice for the enterprises, because the sharing of knowledge as the essential activity in a training requires the professional learning of the trainers.

Confronting the impact of global depression of economy, the employees must struggle to keep their advantageous position in the fierce competition. Therefore, training (initial training or on-the-job training) stands as the necessary device for both the employee and the employer. In the training, although the employees may learn knowledge and techniques of working, they must take time and spirit to assimilate themselves to the new things. The process of assimilation inevitably produces the trainees' rejection and tiredness, which may have influence on the satisfaction with the training and the training efficiency.

The findings of this study suggest that organization should pay more attention to trainees' perceptions of training satisfaction when they are forced to attend remedial training programs. Since the enterprise has approved the budget for the training so as to improve the abilities of its employees, the training must has its positive performance. Therefore, this research suggests that the holder of a training should do some research on the backgrounds of the trainer and the trainee before the activity takes places. Consulting the analysis within this research, the trainer could thus start his or her training course with the topic that the trainees might be interested in. Such consideration makes the trainer more attractive to the

trainee and is possible to eliminate the trainee's rejection and tiredness. The elimination increases the trainee's motive to learn new things and produces the positive interaction between the trainer and the trainee, promoting the satisfaction with and the efficiency of training. Such positive results are helpful to the performance of the businesses.

Moreover, past studies have shown that job satisfaction is related to organizational performance (Ostroff, 1992; Hochwarter, Perrewé, Ferris, and Brymer, 1999), and training affects job satisfaction (Patrick and Owens, 2006). Thus, training satisfaction a positive effect on training effectiveness also connects itself with organizational performance. The study's results contribute to the current research literature. Evaluating training effectiveness as the result of training satisfaction, this study suggests that the higher trainer-trainee fit, the better the training satisfaction is.

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G3 – Decision-making and strategic management

G3.1 **Decision making circumstance in data communicatin business**
Dr. Matti Verkasalo

G3.2 **Designing and implementing a model to examine R&D section's capabilities and fitnesses with emphasis on reversed engineering in a chemical factory**
Mona Benhari

G3.3 **Finnish social housing model as an efficient policy making tool in turbulent economic environment**
Rayko Toshev

G3.4 **Framework for strategic technology management in high-technology enterprise context**
Dr. Kari Sahlman

DECISION MAKING CIRCUMSTANCE IN DATA COMMUNICATION BUSINESS

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ABSTRACT

There is a continuous flow of important business decisions made in companies; product development decisions, manufacturing location decisions, logistics decision, partnership decisions, pricing decisions, personnel decisions, marketing decisions, etc. Decision making circumstance is the collection of relevant factors impacting decision making. Author suggests decision making circumstance to include following factors: a) decision criteria, b) decision making time/urgency, c) contributors, d) decision making method, e) supporting tools and f) business uncertainty. This paper provides an empirical analysis with a focus on data communication consumer product business. The motivation of this study is to increase holistic awareness of business decision making as an opposite to scientific studies focusing only on one of the factors.

This study is based on the other hand on author's personal contribution to business management and on the other hand on author's earlier academic research around the subject. Three typical decision cases are discussed as well as a longer term trend. Intention is to recognize which of the decision circumstance factors, a) …f), are the most relevant ones and therefore attention should be paid on these in order to improve success of decision making.
Decision criteria (a), decision making method (d) and supporting tools (e) are found to be the most relevant factors. Business management should pay attention on these in order to improve decision making process. Contributors (c) and risk management/uncertainty (f) are rather self evident factors and do not require so much attention from management. Timing/urgency (b) is nearly always clearly known and set by business situation.

Keywords: decision making, business management, criteria, circumstance

INTRODUCTION

There is a continuous flow of important business decisions made in companies; product development decisions, manufacturing decisions, marketing decision, logistics decisions, partnership decisions, pricing decisions, personnel decisions, etc. This study is not about any of these particular decisions neither about the decision makers' behaviour but, instead, this study is about the circumstance where decisions are made. *Decision making circumstance* is a collection of relevant factors impacting decision making. Competent business management makes good decisions without recognizing the factors and methodologies. Management is mainly tacit skill rather than explicit skill. However, structuring the *decision making circumstance*, in other words making it explicit, helps in creating mutual understanding of the concept and provides a possibility for developing this important business process.

It is always most relevant for the operative management to adapt to today's *decision making circumstance*. The topical situation and circumstance influences companies in their attempt to achieve business success in short or long term. It would be a disaster if decisions were made either in the mode of historic circumstance or in the imagined future circumstance. History and future need to be taken into account but the decision is to be made today. In order to give perspective, this paper discusses of the trend from history until today and also lines out author's subjective vision of the future. This trend shows the changing nature of the *decision making circumstance*.

RESEARCH METHOD

The research method in this study is an analytical classification of author's experiences that are based on the other hand on author's personal contribution to business management and on the other hand on author's earlier academic research around the subject. Author has 30 years management experience from heavy metal, telecom, electronics and sports equipment business. This experience is the source of this research. As most of the actual documents are property of certain international companies those can not be publicized nor exactly referred. However, author has publicized some of the early research studies that are related to the subject, Verkasalo (1989….2000). This combined industrial and academic experience has made it possible to analyse this challenging subject, *decision making circumstance*, systematically even though author works currently in the industry, not in academy.
Due to the empirical nature of the study the results are lacking of scientific validation. Author invites researchers and practitioners to discuss and research the subject. This study has not been done in any specific company but refers to international business in general with a bias to data communications industry.

The main phases of the study:

- Review of experiences and early research material
- Creation of the proposed *decision making circumstance*
- Analysing and discussing the factors by using three realistic cases
- Discussion of the change from history→ today → future
- Concluding the research results

SCOPE AND OBJECTIVE

The scope of this research is to evaluate the relevance of the proposed factors of *decision making circumstance*. A factor is relevant if it need to be taken into account in decision process. It is a sign of relevance if a factor gets different values *) in different type of decisions. The case discussion simulates this. In such a case the decision taker need to pay actively attention on the possible value changes of the factors. An other sign of relevance is if a factor impacts differently today than in the past. Such a factor requires the decision taker to adapt to the development of business environment. A factor is not a relevant one if it does not react (value does not change) to the type of decision/case or to the time perspective. As author has himself proposed the factors and also carries out the evaluation himself it is rather natural the he can not find missing factors.

Intention of this paper is not to prove that the proposed factors could be widely used with good enough validity. Instead, the intention is on much lower level; to test the proposed definition in three cases and discuss of the relevance of the factors. Wider validity assessment of the results would require external researchers' contribution.

The main objective is to recognize possible areas of future research.

*) Terminology note: *value*. In this study "decision factor" is a synonym for "decision parameter". A parameter can get different values. In the same way factors in this study can get different values. Tables 1 and 2 give values for decision factors.

PROPOSED DECISION MAKING CIRCUMSTANCE

Author has studied decision making process and contributed to these processes widely. He has been modelling the factors that are relevant in business decision making. The research has been made in few phases. In the first phase, end of 80's and beginning of 90's, the focus was merely on decision criteria, Verkasalo et al (1989, 1991, 1992, 1994). That time it was thought that if decision takers can recognize the decision criteria and judge the decision alternatives with these criteria, the decision will obviously be optimal. In the next phase, mid 90's, author's research was focused on the availability of expert information, Verkasalo et al (1996a, 1996b, 1997a, 1997b, 1998). If a manager or team can collect quickly the knowledge and information required in the decision process the portion of intuition will be lower and decision will be a good one with low risk. Since that author's understanding of the decision circumstance has grown. Today, we could say in the third phase, author proposes *decision making circumstance* to include following six factors: a) decision criteria, b) decision making time/urgency, c) contributors, d) decision making method, e) supporting tools and f) business uncertainty.

BUSINESS CASE EXAMPLES

The three cases described in this chapter are in a way real ones even though they are not any particular cases but generalized from several such decisions. As an example author has participated to several production technology decision processes (case 1 below). The cases are not related to any company where author has worked. For the confidentiality reasons any individual business case can not be publicly reported.

Case 1: Production technology decision. Data communication devices include processors, memories, interface components, crystals, displays and many other components. It is of high importance which technology level will be selected. On the other hand technology needs to be mature enough to facilitate short enough time-to-market. On the other hand, too old technology may not keep product portfolio competitive long enough. In order to make industrially solid product the level of technology should be the same with all key components. For example if the selected processor will be of the technology just entering to the mass markets, it would be a mistake the select passive components that are of technology generation already in the "ramp-down" phase. Naturally the selection of technology impacts all key business aspects like: pricing, competitiveness of products, risks, development time, partnerships, etc.

Case 2: Management of documented knowledge. It is a business challenge today to manage documented information. Actually "documented" is not correct word since information is also increasingly in other electrical formats like video scripts, photos, emails and other ad-hoc notes and tool specific data formats. Information overflow may be a bigger problem than lack of information. Access to global data and information storages has made own documentation less important. Information management is today clearly an important area of business management. This generic case refers most concretely a decision where company management shall decide which kind of documentation management concept and related IS tools would best fit with the business requirements. Decision affects office work efficiency, motivation, legacy information management, customer satisfaction and many other important functions.

Case 3: Selection of manufacturing location and related logistics process. Any company trading world wide needs to organize manufacturing and distribution in the best possible way. As an example a company may sell 60% of products in USA, 20% in Europe, 15% in Japan and 5% in rest of Asia. The sold product requires typically localization in terms of user manual language and system configuration parameters. A company has several options to arrange manufacturing and logistics. Two examples: a) it can centralize manufacturing to a sub-contractor in China and use air fright to transport product boxes to each sales country, b) it can manufacture only the main product (like MP3 player) in China and localize the sales boxes (including charger, user manual, warranty cards, etc.) in logistics centres in each market area.

ANALYSIS OF THE CASES

The three cases have been analysed based on author's experience. Since the collection time of this knowledge has been quite long, several decades, the collected information is not perfectly structured but rather a collection of unstructured information. This limits the study to stay on low resolution level without details. Author has done the analysis based on the decision processes where he has been personally involved.

The result of the analysis is presented in table 1. Table 1 lists the values of each *decision circumstance factor* in the three different types of decision cases.

Decision factor	Case 1 Production technology selection	Case 2 Mgmt of documented knowledge	Case 3 Selection of Manufacturing location
a) Criteria	Profit during the entire life-cycle.	Required system functionality	"Door to Door" logistics costs
	Initial investments.	Initial investment.	Initial investment.
	Today's and future product	Life-time costs.	Environmental issues.
	Product quality.	Forecasted number of IS system users.	Flexibility.
	User experience.	Expected user behaviour and users' expectations.	Quality.
	Partner policy; to which "technology camp" company wants	Credibility of IT partner.	Ethical aspects. Fulfillment of social accountability requirements.
	Time to market with new products.	Integration with other IT systems	
	Own technical competence.	Office work efficiency	
	Availability of key HW		
b)Decision making time/urgency	Need to be done in about 2 months.	Need to be done in about 3 months.	Not necessarily very urgent. 3-4 months.
c) Contributors	R&D.	IT management.	CEO.
	Finance.	Finance.	Finance.
	Sales.	Behaviour analysts.	Logistics.
	SW and HW engineering specialists.	All functions.	Sales.
	Product management.	Quality mgmt.	
	After Sales.	Security mgmt	
	Partner management.		
	Production		
d) Decision making method	Rather analytic process. Perhaps 70% based on facts, 30% based on business intuition. Typically similar decision have been made but situation is always unique.	Disciplined method required. Decision can not be based on pure finance and other facts. Hardly no past experince of this type of decisions. Unique.	Very analytic. Mainly based on facts. No past experience of equivalent decision. Unique process.
e) Decision support tools	Facts and consultancy can be purchased for analyst companies or searched from Internet. ERP system used in sales forecasting and profict&loss calculation. An Excel based simulation application used to simulate different scenarios. A dedicated decision process project initiated in the company. Nominated project manager to coordinate and report of the progress in the decision process. Several structured	Rather good statistics from IT systems can be collected. Experimenting some potential IT tools. Structured decision making. Perhaps 3 to5 meetings to make the decision. Excel simulation used to analyze financial parameters.	External logistics consultants can provide lot of fact information of similar cases. Potential service providers can simulate quickly service level and cost of different options. Several articles and studies available from Internet.. ERP system used in transaction statistics collection. A dedicated decision process (project) initiated. Nominated project manger to coordinate and report of the progress in the decision process. Several structured meetings. .
f) Business uncertainty	It is very uncertain which of the technologies will be the winners in 2…3 years. Technology and customer behaviour changes	Rather high uncertainty since at the and the success and utilization rate of an IT system depends of the perceived satisfaction of employees.	Low uncertainty. Typically there are not quick and unexpected changes in the global logistics besides some temporary phenomena and currency fluctuations.

Table 1: Values of *decision making circumstance* factors in the three cases.

REVIEW OF LONGER TERM TREND

Today's *decision making circumstance* is consolidated by simply collecting the values of each factor (table 1) together. The consolidation is in column B of table 2. This represents the typical decision circumstance in 2010 in such business environment where this study has been made.

Then we will look back to discuss about the trend in the past decades. It is evident that the business environment changes all the time and unfortunately the trend is to a more demanding direction. All of the earlier requirements, disciplines and factors remain and new ones enter. Management will be under heavier pressure. On the other hand some factors, like easier collection of information, make decision making easier and quicker. In the column A of table 2 the decision circumstance in 90's is illustrated as author has recorded it.

Thirdly the future development is forecasted. Author did a small scale forecast of the development of decision environment already in 2000, Verkasalo (2000). That forecast has come true to its essential content. It would be glorious to know the factors that make business decisions successful in the future. Author does not have this wisdom. However, author has tried to interpret the developments that are in the initiation phase today but may be of business significance in the future. This is like an extrapolation of the continuous development. Author has illustrated his forecast into the column C of table 2.

Decision factor	A 1990	B 2010	C Future
a) Criteria	Cost efficiency/profit	Cost efficiency/profit	Cost efficiency/profit
	Return on Investment	Return on Investment	Return on Investment
	Quality	Quality	Quality
	Speed	Speed	Speed
	Flexibility	Flexibility	Flexibility
	Competence	Competence	Competence
		Customer Expecations	Customer Expecations
		Trading politics	Trading politics
		Partnerships	Partnerships
		Environmental issues	Environmental issues
		Expected future developement	Expected future developement
		Ethical aspects	Ethical aspects
		IT infrastructure	IT infrastructure
		Employee's behaviour	Employee's behaviour
			Health
			Wellbeing
			Comfort
			Safety
			Image
			Attractiveness
b) Decision making time/urgency	Typically from 1 month to 6 months	From few weeks to few months.	Shortens
c) Contributors	Company's top management including all functions	Company's top management including all functions	Company's top management including all functions
	Middle management	Middle management	Middle management
	Experts	Experts	Experts
		Partner management	Partner management
		User behaviour analysts	User behaviour analysts
			Key customers
d) Decision making method	Structured and analytic decision analysis.	Decisions are mainly analytic. Decision can not be based purely on facts but intuitive judging is also needed.	More contributive management model.
e) Decision support tools	Financial spread sheet calucations.	Transparent global information systems support significantly decision making. Plenty of valid information is available quickly from Internet and other data	Video meetings with own smart phones or tablet computers.
	Several stand-alone IT systems or other SW tools.	Video meetings.	Open information coordiantion system with visual and intuitive interface.
	Documents and presenattions.	Conventional Office tools like Excel facilitate quick and easy simulations and graphic visualisation.	Real time information during the decision process
	Extenal consultants	Plenty of possibilities to utilize domestic or international consultants.	Remote commenting and voting features.
	Structured and fixed decision process.	Very often structured decision process which adapts to changes during the	Contributors are "on line" at the time point of decision statement.
	Face-to-face meetings, lots of traveling.		Factual information about customer behaviour.
f) Business uncertainty	Short term (<1 year) busiess outlook rather stable.	Business uncertainty varies depending on the type of decision.	Global conflicts and catastrophes

Table 2: Change in factors' values over the time.

RELEVANCE OF FACTORS, CONCLUSIONS

The intention of this paper was to experiment the proposed *decision making circumstance* factors in three practical decision cases and to discuss their behaviour over the time. Tables 1 and table 2 are the key results. A factor is relevant if its value is different in the three cases (table 1) and/or the value changes over the time (table 2). The relevance of each factor, based on author's analysis, is following:

a) "Decision criteria" factor is very relevant as it gets significantly different values in the cases and also the value changes over the time.
b) "Decision making time/urgency" factor does not change very much and is rather self evident.
c) "Contributors" factor gets different values depending on the decision cases. Also new contributors are entering gradually over the time.
d) "Decision making method" factor is very relevant as it gets significantly different values in the cases and also the value changes over the time. Method is many times even unique.
e) "Supporting tools" factor is very relevant as it gets significantly different values in the cases and also the value changes over the time.
f) "Business uncertainty" factor gets different values depending on the decision cases.

All of the factors have at least some level of relevance. However, if business management wants to improve decision making they should recognize clearly decision criteria, decision making method and supporting tools. These are the factors are not self evident and require therefore special attention. Then contributors and risk management/uncertainty are the next relevant factors for successful business decision making. Timing/urgency is the most self evident and does not require so much special attention from management.

At least following areas are potential for further research:

1. The most relevant factors; decision criteria, decision making methodology and utilization of supporting decision tools are worth of further research.
2. It would be also interesting to study if the factors are orthogonal or do they have dependability on each other. Example: if there are many contributors shall the decision method be different compared to a decision process with only few contributors?
3. To survey if there are some additional factors shaping the *decision making circumstance*.
4. External testing and validation (so far author has done the study in a limited environment).
5. Literature study.

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DESIGNING AND IMPLEMENTING A MODEL TO EXAMIN R&D SECTION´S CAPABILITIES AND FITNESSES WITH EMPHASIS ON REVERSED ENGINEERING IN A CHEMICAL FACTORY

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ABSTRACT

Today, research and development and related activities to access new technologies in the industrial world have been challenging activities. Although the research and industrial development companies in developed countries have been living for thirty years with increasing importance of R&D continuously, but developing countries recently have realized its importance. Undoubtedly R&D units were known as Technology pillars and are unique resources of innovation, creating R&D units and institutes or developing old ones to new effective ones for developing countries are inevitable issues.

There are various methods to access the Technologies and one of the most important ones, especially among developing countries is Reverse engineering which is Consciousness method taken from exist Technology.

This paper also reviews research background of (R & D) and reverse engineering, implements simulation software modeling to achieve the most effective parameters and their relationships and offer strategies for optimal per unit R & D and access to technologies of modern examined. This study contains R & D department of a chemical factory as selected population which is one of the important industrial factories in Iran.
In conclusion some key effective factors have been extracted through this simulation. The company can consider them to develop R&D unit and improve the product quality.

Keywords: Research and Development (R&D), Reverse engineering**,** Technology Transfer, System dynamic.

INTRODUCTION

Research, development and management are the pillars of creation, development and utilization of technology and they are the needs of economic and social development in every country, in the developing countries which are seeking industrial and economic self-reliance, policy and planning research programs and development and management of practices impact on these activities are considered as priorities for national, industrial and manufacturing activities. Expansion and enhance of R & D activities, particularly "industrial

research ", requires understanding the factors affecting research and development process and designing policies and effective activities of such mechanisms. In competitive conditions of the current industrial world, doing research and development activities is one of the most effective things that managers of economic enterprises can take on and in industrialized countries of the world, the costs allocated to these activities are being increased day by day, on the other hand referring to the research and development without creating the necessary infrastructure units such as: organizational structure, human resources characteristics and management of these organizations causes the failure of research and development process of economic institutions.[12]

Process of R & D includes: basic research, applied research and development. By using basic research, the scientific findings are presented in the form of hypothesis, theories and general rules and in the next stage, it would be the applied research which determines the possible applications for basic research findings. The stage of development, scientific knowledge obtained from basic research and applied research is applied in order to provide new and developed products or processes and innovation can occur. The main centers of the R & D process consists of industrial research institutes, academic research institutions and government R & D centers. Reverse engineering is extraction and development of technical information from available products. This method unlike the direct designing process meant to production according to customer requirements and the initial idea is based on the engineering analysis. [3]

Many activities in this area are done with different goals daily. Extraction of technical knowledge designed by R & D units in different industries, providing technical documentation of industrial equipment and probably copying the products are some examples in this field. Developing countries to access complicated technologies require a method that fills the technology gap between these countries and the developed countries at the right time and among different methods of having access to technology, reverse engineering is the most appropriate method.

This research was done in the context of systemic thought and to achieve research objectives and answer of research questions, System Dynamics modeling has been used. Modeling dynamic systems is an essential tool in systemic thought that in order to better understand the behavior of the system; imaging and strengthening the conceptive models and displaying the behavior of system are used. Since diversity of effective factors is very significant on issues, in order to obtain acceptable solutions, the least important factors are omitted by using modeling in the study. The general category type of research will also be an applied research.
This study utilizes a model (simulation), which includes relations with variables methods in reverse engineering in R & D units which will be done. This model can be considered as a new process in popular and applied industries. And the places where there is no new scientific and systematic approach in these projects, so this research and simulations can greatly help managers in making decisions and having reasonable controls.

Thus, at first there have been gathered interviews and questionnaires with key members collaboration and make a systematic relation between variables and suitable parameters base on model and achieved the desired data will be collected and model validation is done

and CLD related to basic parameters can be drawn. Then modeling using Vensim simulation software based on raw data and descriptive statistics are done and the parameter sensitivity analyses also take place.

Finally, based on the model output and parameters sensitivity analysis software, necessary suggestions and performed conclusions are provided.

THE ROLE OF INDUSTRIAL RESEARCH ACTIVITIES AND ENGINEERING SERVICES IN THE PROCESSES OF ACQUIRING TECHNOLOGY

The experiences of advanced countries suggests that technological progress in these countries owe R & D activities and technological infrastructure more than anything and without implementing such activities there is no way to achieve the desired technology for that, though by buying the product or purchase process, the required parts can be obtained, but even successful technology business by buying technology (research and development activities necessary for building or research strategies to produce copy that is necessary) also requires research activities and industrial engineering services. For example, before attempting to determine how to access to technology, knowledge and action for defining technology needed to meet demands and needs of development projects such countries need some activities which won't be fulfilled without collaboration of involved ones engineering services directly. [11], [4], [18]

SELECTING APPROPRIATE TECHNOLOGY AND RESEARCH AND DEVELOPMENT REQUIRED ACTIVITIES

The process of selecting technology and appropriate product includes all actions and activities which are contiguous with the objectives, conditions and specifications and technological needs to determine the most appropriate technology requirements and also the most appropriate strategy to achieve the goals is done by considering the circumstances and technical, economic and legal relations. This process typically includes steps such follows:
[6], [1], [2], [8]

1- Information on market needs consumer preferences and market traction for new products.

2 - Information about status of competition, situation of required innovation, research and development activities, products and environmental threats.

3- Having Information about the required global situation of technology and explanations of their pattern in some period of times by using technology forecasting techniques.

4 - Identification of technical and scientific facilities of country and possibility of access to materials, energy, and production processes.

5 - Analysis of investment company status among others in terms of scientific, technical, economic support and technical ability, communication and marketing.

6 - Strategic planning to determine and select the required technology, according to data collected.

7 - Designing strategies to achieve product and selecting the most appropriate strategy (according to the results of technical and economic feasibility studies later we will pay attention to this issue.)

Marketing efforts, policy and strategic planning and selecting the required technology to achieve the set of activities that make up except those involved with research and development activities and research and development, so reaching them is not possible except with effective management of information and technical experiences of engineers. The sensitivity of this action is so much in a way if investments policy and managements not to be done accurately and according to practical techniques and if a comprehensive analysis not to be done, the rest innovation activities will be overwhelmed and they eventually might lead to investment plan failure.

MAJOR RESEARCH AND DEVELOPMENT ACTIVITIES IN THE STAGES OF REVERSE ENGINEERING PROCESS

[9], [13], [14], [10]
1 - Controlling the possible technical and economic studies, making plans to copy a subset of product or product requirements inside the factory.
2 - Researching for understanding mechanisms of functioning components for realization of working mission for products and discovering the relationships between components during operation.
3 - Departing the components that we have decided to copy them and registering charts for the products and its details during operation.
4 - Providing maps and photos, or piece or pieces that they're going to be copied.
5 - Identifying, testing and determining the raw materials used to manufacture any component of product.
6 - Identifying, testing and diagnosis process for production of any component of product.
7 - Identifying, testing and diagnosis of complementary operation performed to achieve mechanical, physical, metallurgical, chemical properties… which are required.
8 - Detecting required machineries and tools for manufacturing and assembly.
9 - Compiling technical knowledge for production and assembly and its components.
10 - Preparing production drawings, maps, templates, models and tools needed for production and control stages.
11 - Monitoring the prototyping operation specifically or under direct supervision.
12 - Controlling samples made and matching them with the profile of desired standards.
13 - Assessing and analyzing test results and in case of necessary, revision of sizes and tolerances.
14 - Designing production and estimating required machinery and equipment.
15 - Planning of factory and designing factory production and assembly line.

METHODS

This paper aims to achieve a model to evaluate the capabilities and competencies of R & D of a chemical factory based on modeling system. This model is provided to managers and decision makers as a tool and it plays the role of easing in decision process and opting organizational strategies. So according to this view, this article is considered in the category

of applied research. On the other hand the type of approach used in the paper is in a way that by dynamic modeling, the effective components on planning present a new model and it solves the problems that current planning methods are facing with. In this study it is tried that modeling (simulation) and all factors and important variables and influencing patterns, trends empowerment of R & D unit for the chemical industry to be considered with an approach of reverse engineering in order to strengthen R & D unit. [8], [15], [19]
First stage: gathering effective factors on research and determining the primary assumptions
Second stage: determining the most important factors affecting research and inserting them in the initial model and draw CLD to determine relationships between factors and variables for the basic model.
Third stage: extending the primary model and finding datum and formulas for model and model validation
Fourth stage: testing Software Model (simulated) [17], [20]

Introducing the basic components in capability of Research and Development (R&D) of the chemical Factory

[7], [8], [19]
This section is based on offering presumptions that simply realize modeling process and it is attempted to present the model which can be implemented in Vensim software.
Assumptions made are extracted based on the information of a Chemical factory and interviews with senior managers and library studies and the most effective variables and essential factors are mentioned bellow:
1 - Professional and skilled personnel (manpower)
2 - Identification of risk factors
3 - Market and customers needs
4 - If necessary interaction with industries and marketing and production units
5 - System inputs include raw and new materials (new requirements)
6 - Technical Knowledge
7 - Sufficient capital (cash flow)
8 - Cost market
9 - Planning
10 - Economic blockade
11 - Project Manager
12 - Skillful and risky management of R & D

Model Validation Test

In order to demonstrate the model validity, we use real tests K Square test to explain credibility. Since based on calculations done on questionnaires and interviews, the most effective factors and variables in the model were determined, and information relevant to the years 2001 to 2011 are available.
So by putting this information in the model, the information of next year is predicted and they are measured with realities so the credit degree of model could be provided.

It should be mentioned that information and figures of influential factors, including system inputs (raw materials, equipment, technical knowledge), human resources, including (motivation, working group, spontaneous, education, good environment, planning and project control, management empowerment and the number of projects done in R & D through the questionnaire were determined. Also system inputs, planning and control of projects, skillful management of Research and Development and human resources were considered as independent variables and the numbers of projects R & D were considered as the dependent variables.

The aim is that according to the four-term factors: 1) system inputs, 2) Planning and Project control, 3) strong management, 4) Human Resources with a number of projects to reach an acceptable quality.

Model validation test by using of real data test & square of KAY :

Human Resources	Strong management of R&D unit	Planning & Project Control	System Input	Number of ended project in R&D unit	Year
6.45	5.6	7.75	6	2	2001
6.75	5.92	7	6.16	5	2002
6.8	6.08	7.75	6.4	7	2003
6.55	6	8	6.75	2	2004
6.45	5.92	7.5	6.66	1	2005
6.4	5.33	7.25	6.5	1	2006
6.2	5.41	7.25	6.33	3	2007
5.9	5.5	6.75	6.41	0	2008
5.6	5.33	6.75	6.08	0	2009
4.95	5.1	6.5	5.91	7	2010
7.6	7	8	7.6	5	2011
7.6	7	8	7.6	5	EI- Model (fit)
2.949	2.872	0.983	2.237	$X^2_{(n-1)}=x^2_{9,0/05}$	X^2

Table1: Model validation.

According to figures contained in the questionnaire, the average number of variables and factors extracted from 2001-2011, they have been mentioned in above table and then for

credibility and accuracy of model operation, the K Square test was measured by the following formula:

$$X^2_{(n-1)} = \sum \frac{Oi - Ei}{Ei}$$

And the figures of ^2X was extracted according to the above table; X^2 which was provided according to K Square test is $16.92 = X^2_{0/05,9}$ and since X^2 is four variables of model and is less than 16.92, so the modeling assumption is accurate and according to the figures and information listed above, the model is accepted with 0.95 confidence.

C.L.D Draw

After extracting the effective parameters on model, in the second step of modeling, the causal relations between the parameters must be considered, so for this purpose, we extract C.L.D. It is noteworthy that due to the volume of datum and the high number of parameters affecting the issue, single-step extraction of C.L.D is not feasible.

Therefore for the purpose of understanding it easier, we divided the casual model of the issue into five stages and in each stage a loop of causal model has been drawn; and then finally according to the defined relations, we link each stage to the other stages and each component to the other components to achieve the ultimate causal model of the problem. Finally, the effective parameters of the model simulation, sensitivity analysis and the related results are also presented.

DRAW OF C.L.D

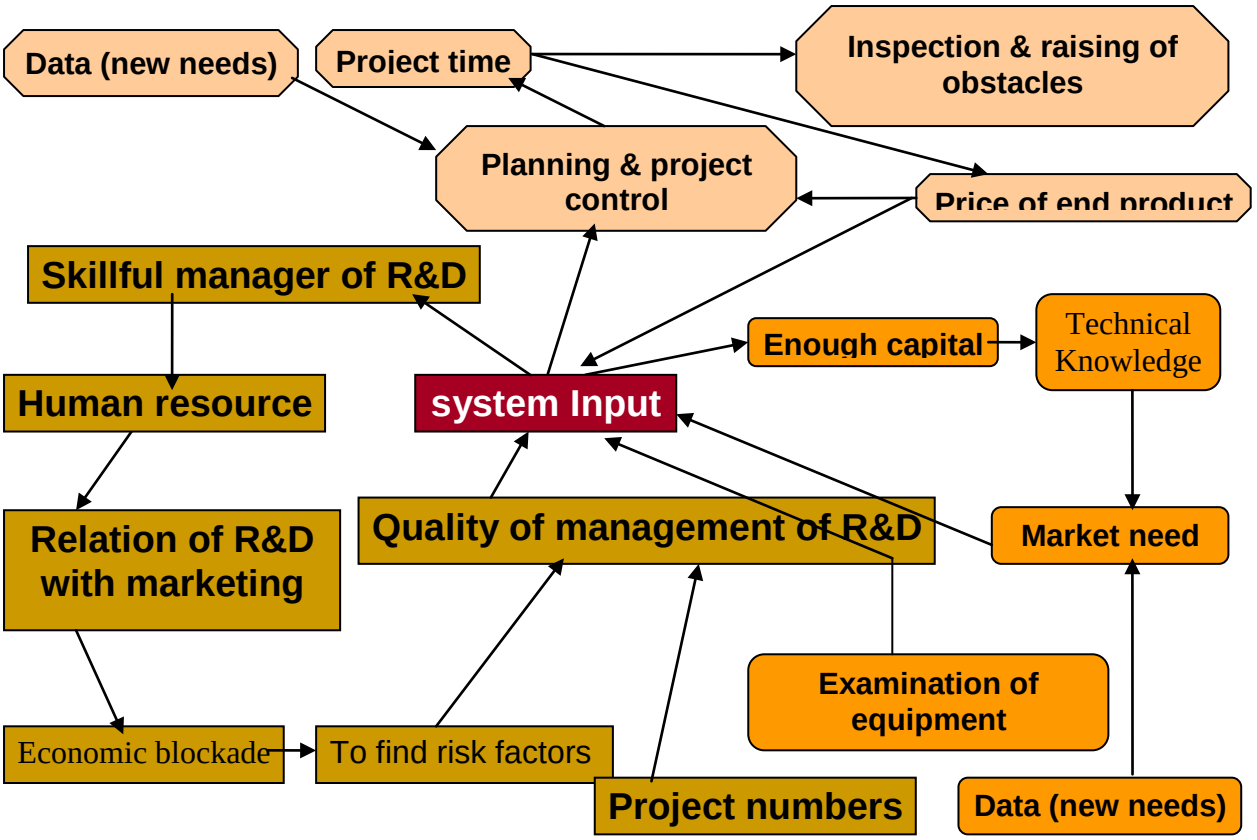


Chart 1: C.L.D (casual loop diagram).

Draw of chart of Stock & Flow by Vensim software:

[5], [16]

Formula tray relation of Regression for Number of ended project in R&D unit:

Number = _0.61 Input+0.07 Planning control+0.72 Managenent of R&D_0.34 Human Resources

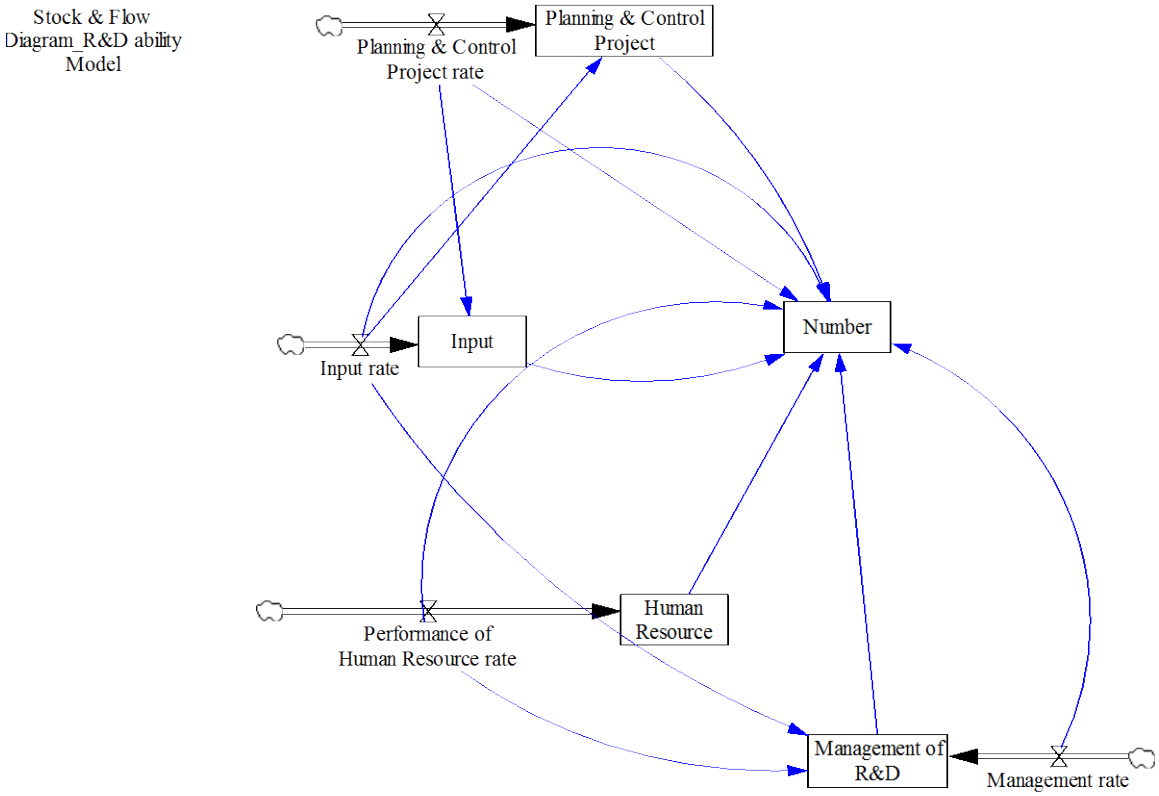


Chart 2: stack and flow.

Multiple Graphs relevant to the main parameters of the model

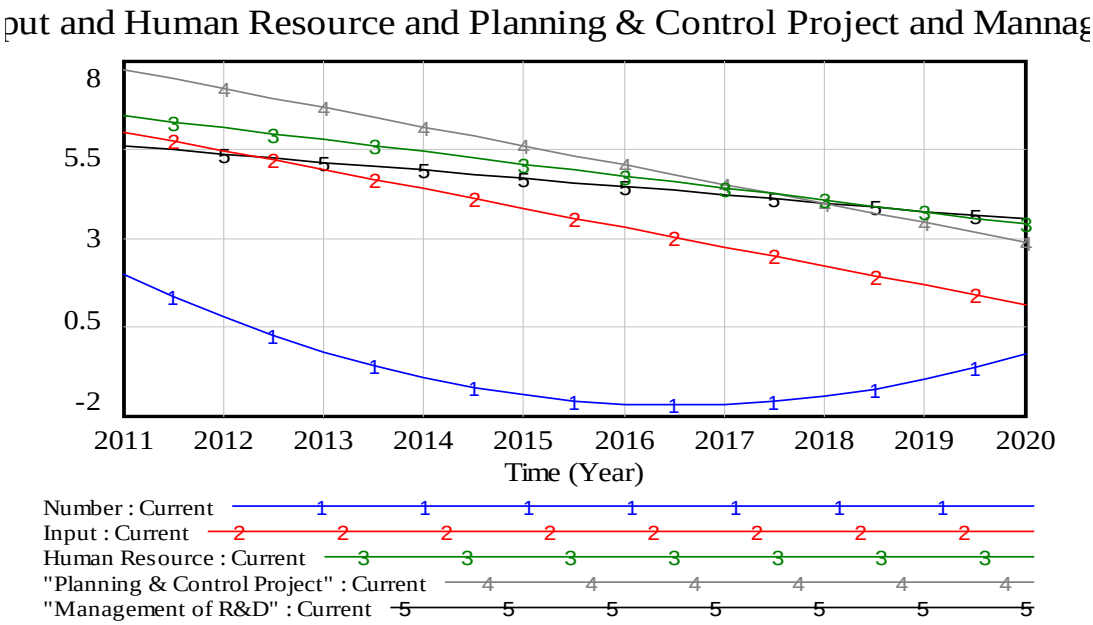
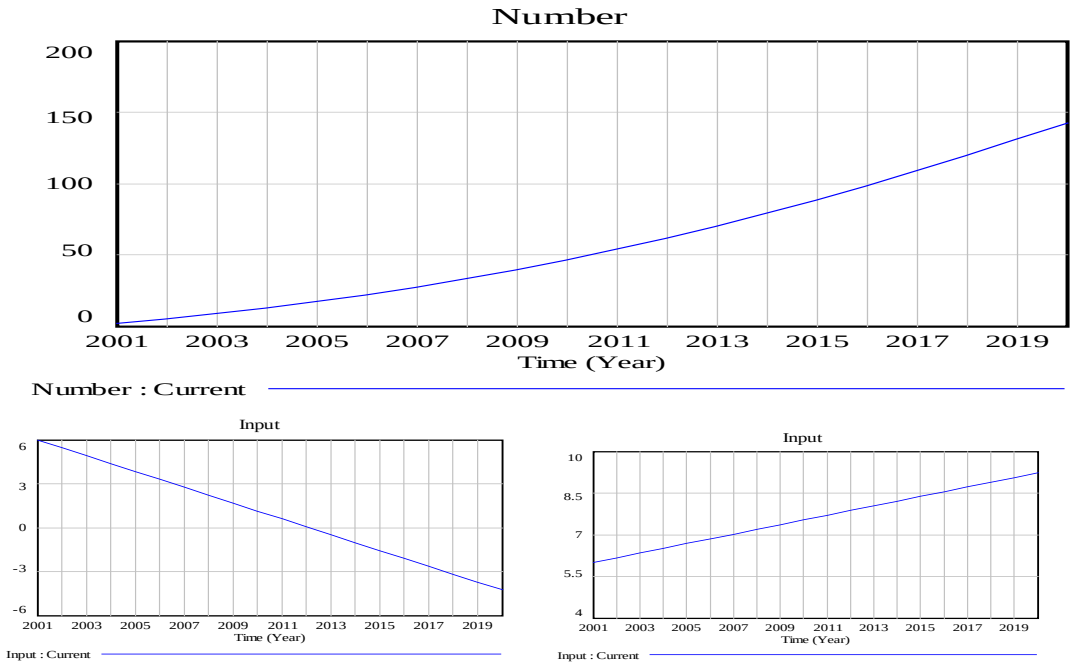


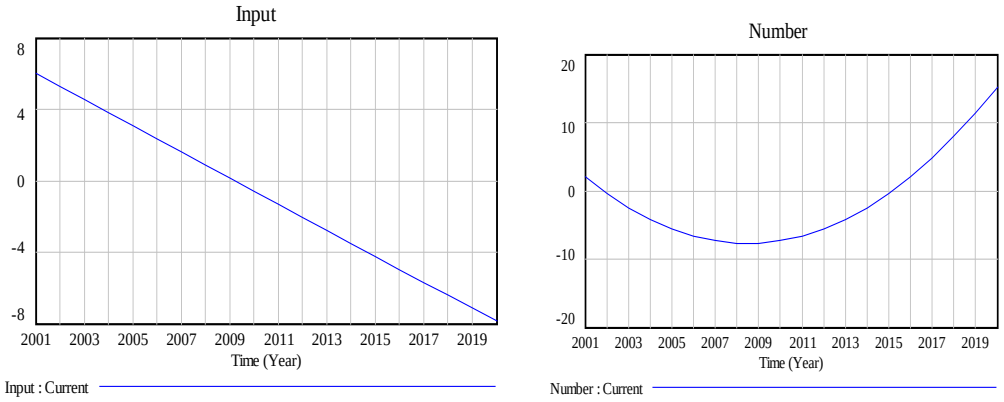
Chart3: Multiple Charts of the basic model variable.

Statistical analysis (sensitivity analysis):



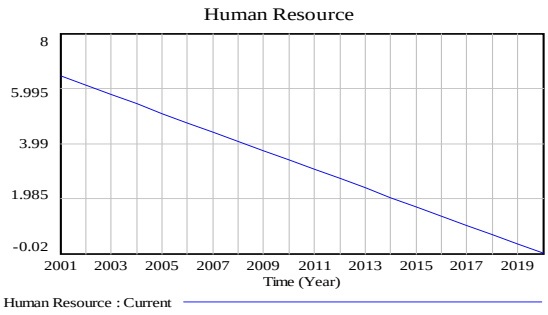
Year	Primary state for system input	Optimistic state for system input	Project numbers in optimistic conditions
2011	0.6	7.7	53.8
2020	-4.2	9.23	142.4

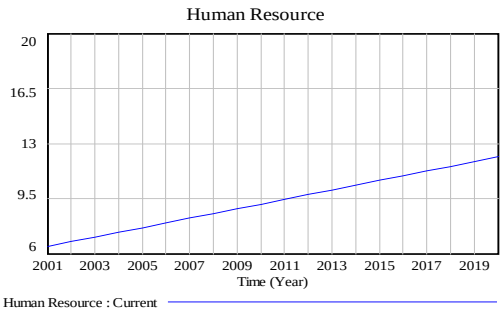
Chart 4: Optimistic level conditions for System Input, Coefficient change from -0.61 to +0.1.

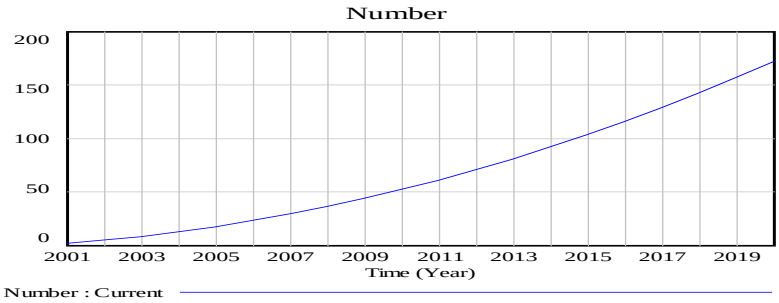


Year	Primary state for system input	Optimistic state for system input	Project numbers in optimistic conditions
2011	0.6	-1.3	-6.6
2020	-4.2	-7.8	15.23

Chart 5: Pessimistic level conditions for system input, Coefficient change from -0.61 to -0.80.

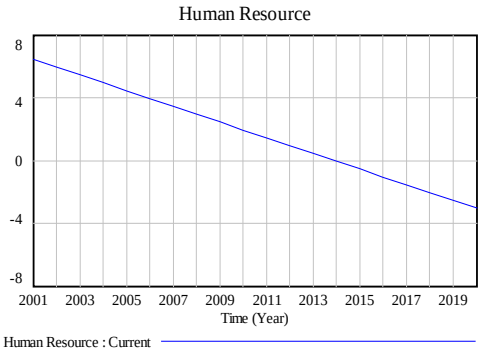


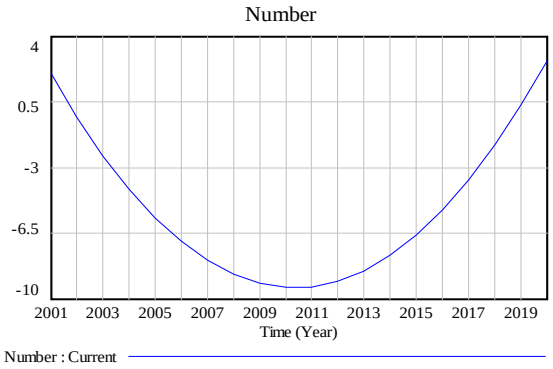




Year	Primary state for human resource	Optimistic condition for human resource	Project numbers in optimistic conditions
2011	3.05	9.4	60.9
2020	-0.01	12.15	171.8

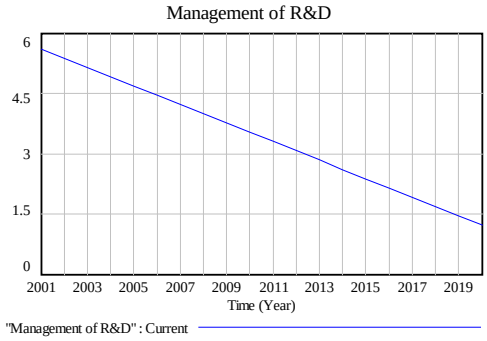
Chart 6: Optimistic level conditions for Human Resource, Coefficient change from -0.34 to +0.3.

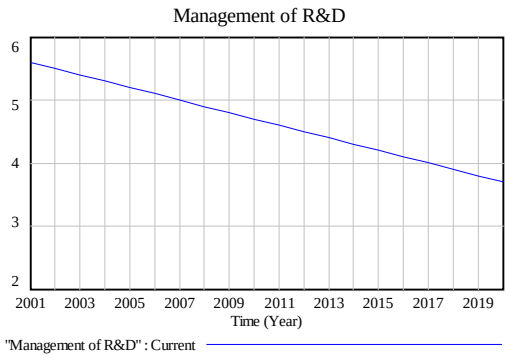


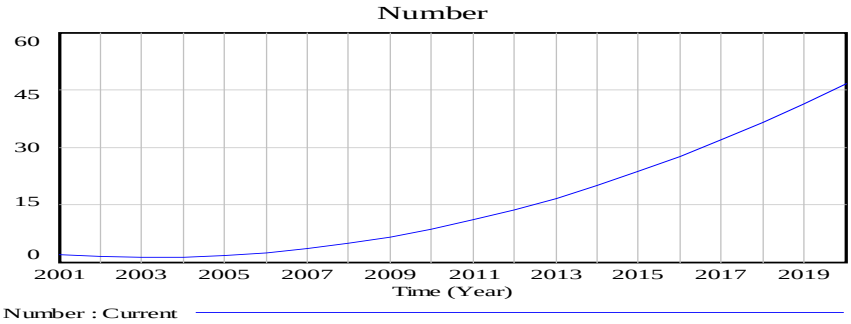


Year	Primary state for human resource	Optimistic condition for human resource	Project numbers in optimistic conditions
2011	3.05	1.45	-9.36
2020	-0.01	-3.05	2.69

Chart 7: Pessimistic level conditions for Human Resource, Coefficient change from -0.34 to -0.5.

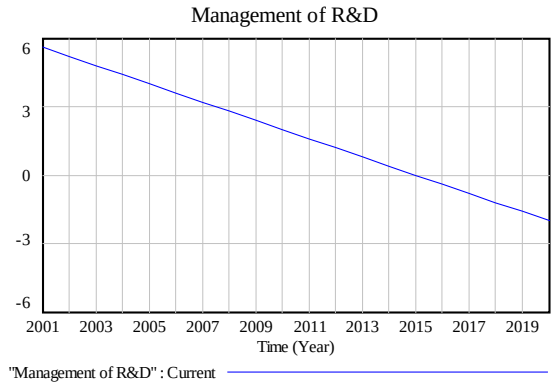


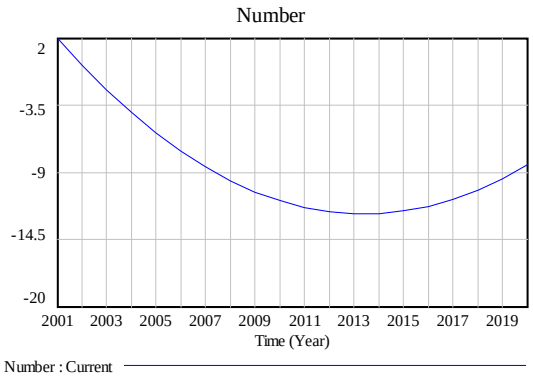




year	Primary state of R&D	Optimistic state of R&D	Project numbers in optimistic conditions
2011	3.3	4.6	10.99
2020	1.23	3.69	46. 63

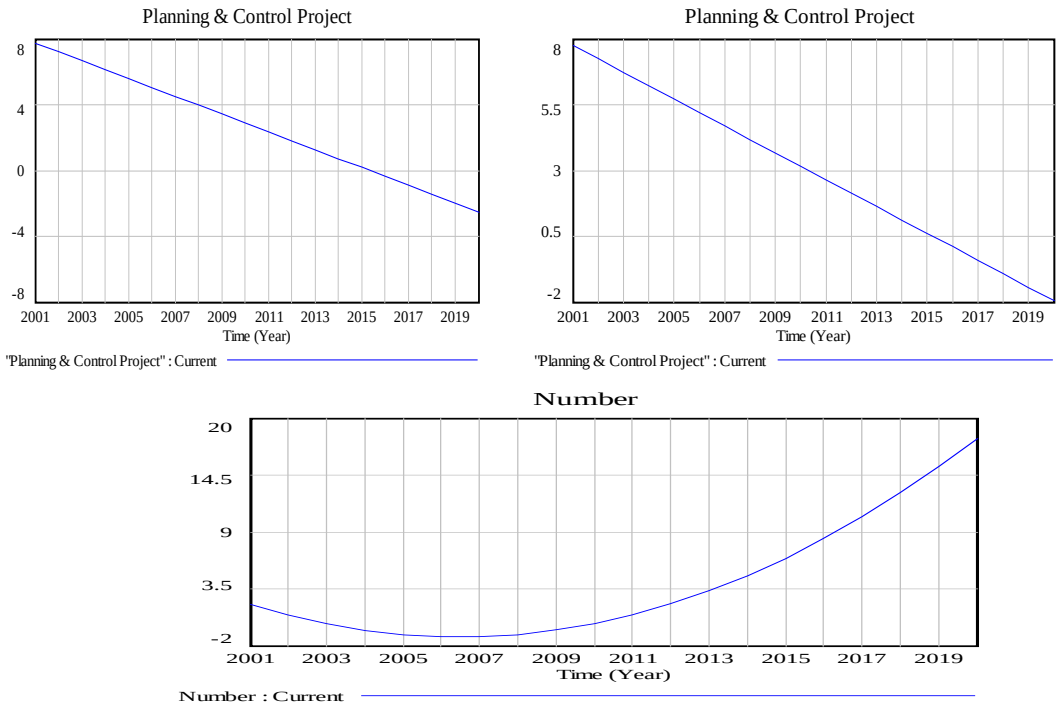
Chart 8: Optimistic level conditions for Management of R&D, Coefficient change from 0.72 to 0.85.





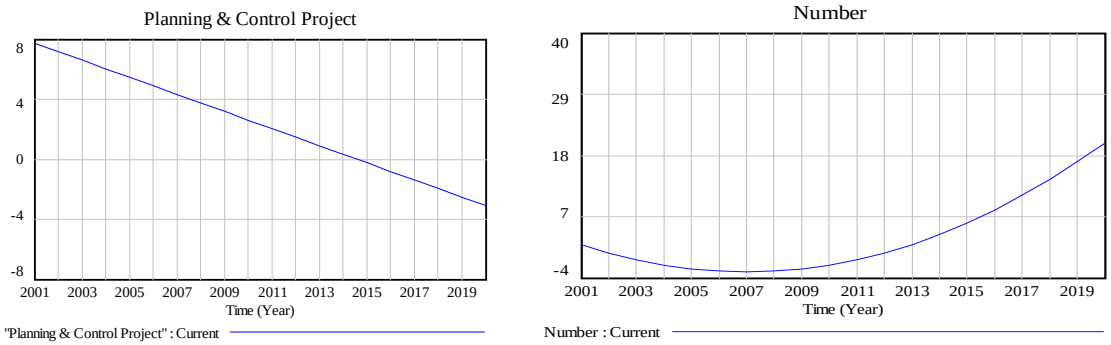
year	Primary state for R&D Management	Pessimistic conditions for R&D management	Project numbers in pessimistic conditions
2011	3.3	1.6	-11.88
2020	1.23	-2	-8.3

Chart 9: Pessimistic level conditions for Management of R&D, Coefficient change from 0.72 to 0.55.



Year	Primary state for planning & project control	Optimistic state for planning & project control	Project numbers in optimistic conditions
2011	2.39	2.65	0.99
2020	-2.5	-1.9	19.05

Chart 10: Optimistic level conditions for Planning & Project control of R&D, Coefficient change from 0.07 to 0.10.



Year	Primary state for planning & project control of R&D	Pessimistic state for planning & project control of R&D	Project numbers in pessimistic conditions
2011	2.39	2.05	-0.7
2020	-2.5	-3.08	20.29

Chart 11: Pessimistic level conditions for Planning & Project control of R&D, Coefficient change from 0.07 to 0.04.

CONCLUSIONS

As noted, the purpose of this paper is presenting a local model to consider capabilities and abilities of Research and Development unit by emphasizing on reverse engineering in a Chemical Factory. Based on the pattern provided, indicators and parameters to measure Features and capabilities of R & D unit are available.

In this model, some of the basic parameters which were measured, analyzed based on sensitivity analysis include:

Number of Projects done in R & D unit, system inputs such as raw materials and new requirements, professional and skilled manpower, skilled management of R & D, Project Planning and Control of research and development project in analyzing the sensitivity of above indices and parameters, some results were obtained. By eliminating restrictions of indices, it means in terms of optimism for the variables, we can mostly observe that growth is very rapid rate for parameters and variables and also features R & D unit and ultimately the growth of parameters lead to significant increase in the rate of the number of projects conducted by R & D unit. Also by considering the conditions of reverse condition it means, the sensitivity test of variables in terms of increase of barriers in the parameters, we can mostly witness decrease of parameters and number of projects done in R & D.

Finally by reviewing the outputs of model software graphs and sensitivity test of parameters and effective factors for model, in this article the capabilities and abilities of Research and development (R & D) of chemical factory have been determined.

We can use these indices and variables to achieve specific goals specific and by comparing them relatively with other industries of R & D and or by comparing them with research and development units of industrial plants located in other countries, the efficiency and effectiveness of R & D unit in the chemical factory to be measured.

Finally, this model can be used to identify desired features and capabilities of R & D and to use required managements to reach them and they be used to successfully control the programs. The model has the ability to generalize and use in most application areas for selection of strategies, policies and research and development projects and access to new technology and we can observe the basic parameters of the model by its effect on the capabilities and abilities of research and development unit.

By observing all tables and charts of the basic parameters we can conclude that in spite of reduced volatility variables and factors in the model during the years 2001-2010, the increase of projects number in R & D unit of chemical factory has had a good condition. This increase is relevant to the urgency and necessity of unfinished projects which are being done by the important factor of R & D Management.

According to the relations of all the basic parameters and doing regression and the corresponding formula model, we can conclude that the most effective factor on the number of projects is the factor of management, planning and control of projects and R & D

unit of the chemical factory has a good condition in terms of R & D management, and the reason of this issue in addition to observing relations of variables and formulas coefficients, in addition to the information and graphs is due to necessity and emergency point of unfinished projects and coordination of the main parameters by skillful of Research and development (R & D).

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FINNISH SOCIAL HOUSING MODEL AS AN EFFICIENT POLICY MAKING TOOL IN TURBULENT ECONOMIC ENVIRONMENT

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ABSTRACT

This paper explores how effective a social housing policy can be in solving the challenging situation in North Africa and the Middle East. Economic pressure on food and energy prices combined with high unemployment among young people has triggered massive protests against long ruling regimes and dictators. It is obvious that the communication technology progress is uniting the voice of people from lower society levels and they start to feel much stronger in the act of searching freedom and equal social opportunities. Regimes in Tunis and Egypt were overthrown by rioting masses of demonstrators. Even long ruling dynasties from Middle East had to re-evaluate their policies and try to provide better conditions for prosperous future to their citizens. As one of the predominant factors that sparkles the crisis is the fact that these countries have high present of homeless young people, social housing can be seen as an effective tool to solve the needs of this people. Comparing these countries with the Finnish model gives the new people elected governors a lot of opportunities, while at the same time highlights major differences in the developing cycles of the real estate business.

Keywords: Decision support system, sense and respond, analytical hierarchical process

INTRODUCTION

This study discusses pragmatic business considerations in decision making. It considers the multi-focused strategy theory aspects of the decision-making process for TVT and relates the various decision-making models to that process. It is based on a vast collection of empirical interviews, secondary data and inside knowledge of city of Turku and examines the potential effects of critical factors recourse allocation design approach on the social housing, in context of national policy issues as well as local agendas.

Reallocating resources in housing market in times of global economic turbulence triggered from derivatives written over the same market segment is a responsible task. In ensuring affordability of owner-occupied and private rental housing and enhancing tenants living experience, management have to make decisions for the future of the company based on information dispatched from expectations for the capital flows and level of service needed.

The different business layers in real estate companies can generate versatile signals which create information gaps and retreat efficient decision making from day to day operations. To fill these breaches, we start from the company's systems and processes, which support customer deliverables. They are applicable sources for searching up much needed relevant information about whether or not the organization is satisfying the customer.

Front desk staff and maintenance process owners acquire first hand information about the demanded level of service and operational effectiveness. They gather experience about what customers expect from the company and provide estimate information for the operation management and company's network of service and product suppliers. When transmitted on to top management centre and executives, this information is filtered through the process; it does not contain too much relevant data for potential clients or competitor analysis. It would be inefficient to disregard free and easily accessible customer information accumulated inside the company. Utilizing effectively this knowledge requires flexible strategy orientation combined with proactive identification and assessment of service concepts. Considering the long time span of the business cycle in real estate market and the difficulties in forecasts in volatile economy, top management need to deal with heterogeneous hierarchy of variables, cost time quality and flexibility taking the main priority. Structured DSS prevent executives from setting up main business strategy goals, based on expectations about experience of customer's expectation, and establish high level of sensitivity enough to comply with turbulent business environment.

FINNISH HOUSING MARKET OVERVIEW

Finland is one of the first countries to provide public housing. In 1909 wooden houses designed by the architect A. Nyberg were built in Helsinki for the city's workers. The residents were mainly working-class families with several children. The apartments were constructed for communal living for five people per room, sometimes up to eight, equipped with basic utilities running water, a pantry and an attic cupboard. Electric lighting was installed in 1918. On other hand private real estate market in Finland is relatively young comparing to other European countries. The driving forces during the last 60 years have been migration from rural area to urban cities and it is dominated by the lack of capital. Nordic climate conditions and new demanding sustainability factors set the building price relatively high. There are complete set of regulations concerning the location, building processes, as well as the business operations to be followed. One third of all Finnish homes are rentals, situated in concentrated urban areas. Major market trend is the building of new houses, while renovation of old property is less than third. Government is using the housing market as a tool to implements political goals like social and economical equality, economic growth and stability, and environmental issues.

RESEARCH BACKGROUND

The roots of decision theory lay within models of conscious judgment and rational choice. Real estate companies are using models for optimal pricing and allocation of assets, based on assessment of performance and strategic goals. At the same time real estate economics does the research of real estate trends focus on the business and structural changes

impacting the industry. They both analyse the equilibrium between supply and demand, taking into consideration urban economics, spatial economics, extensive research, surveys on customer satisfaction and finance. In the increasingly complex world of real estate business, it is hard to balance multiple day to day operation decisions required with complex development projects and cardinal shareholders goals. Often, judgments are made relative to current expectations and current business constraints. While a decision-maker may believe in the required optimum resource allocation levels, as dictated by optimal pricing model, the final decision may/will be influenced by factors outside the parameters of that model. Yet, as Nick French points, much of decision theory does not lie entirely within any one discipline: it draws upon psychology, economics, mathematics, statistics, social sciences and many other areas of study.

Contemporary view of progression of economic values, spread out by Pine and Gilmore, puts experience and customer delight at the top of the competitive advantages and pricing level possibilities. It brings customers coming back for more, creates interest in new customers and distinguishes your company from the competition.

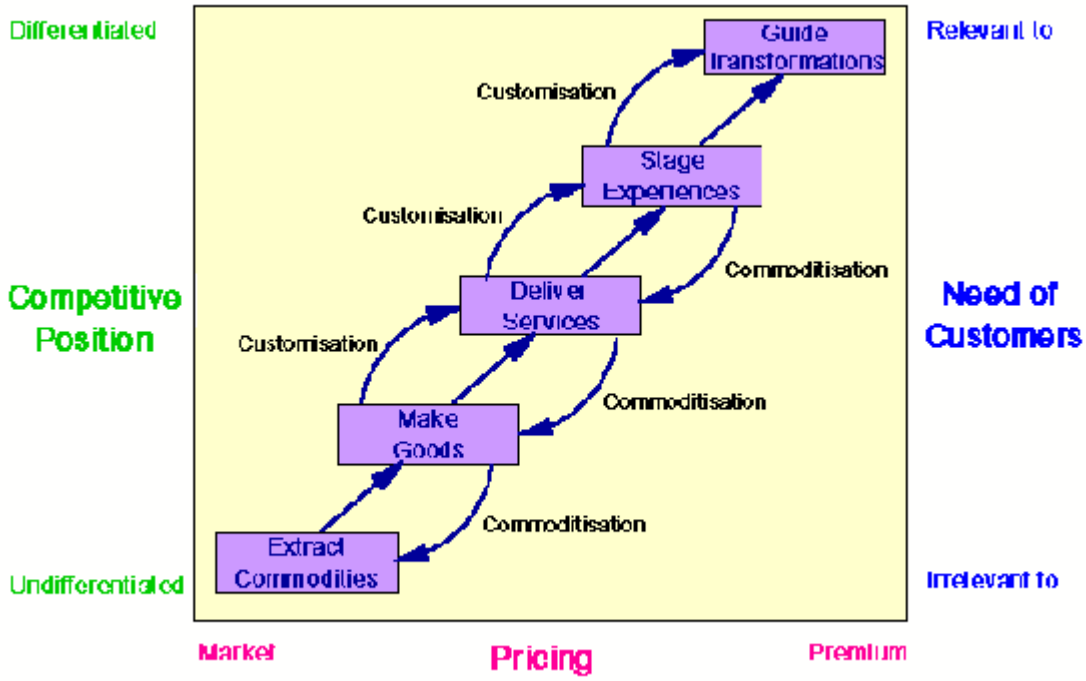


Figure 1 : Progression of economic values.

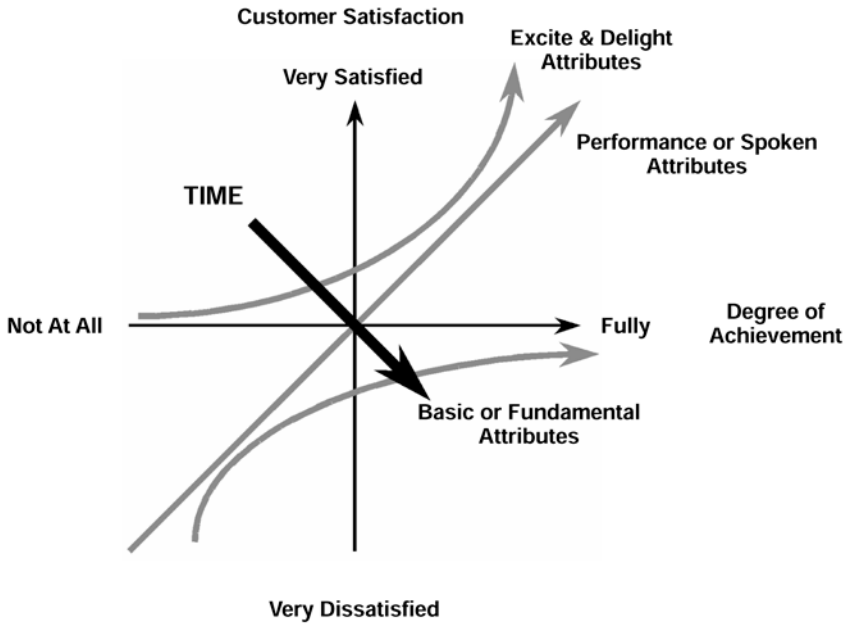
Real estate and service industries start to implement the power of a mass customization orientation. Front desk and call centres are leveraging agent-assisted technology to handle customers' inquiries and replenish data relevant for structural decision making. The process variation gets minimized with the expertise usage of that data as operators need to modify response only because of something the customer says or needs, as opposed to varying everything, every time. (Adsit, 2009).

At the same time to be able to get sustainable effect, one needs deep expertise in sensing customer behaviour as well as implementation of value added processes that are hard to

copy. Our case study in Finnish housing market targets the application of Customer Delight model in construction of DSS in making reasoned judgement in this selection and taking actual actions in re-allocation of resources.

CUSTOMER DELIGHT

The model of Dr. Noriaki Kano is aimed at capturing the voice of the customer for requirements for products and service. Originally conceived in the 1970s as a quality tool for obtaining a good match of customer need and product feature and function, project managers can apply this tool not only for grading requirements but also for evaluating budget allocations and priorities and for assessing qualitative risks. In this regard, Kano models are quite useful for project managers who must make dollar decisions about where discretionary funds can be best leveraged for business value.



Source: Kano *et al.* (1984)

Figure 2: Customer Delight Model.

Kano really only addresses two of the focus areas already described: customer perspective and product excellence. The Kano model pretty much ignores operational effectiveness, except as operational effectiveness is reflected in product or service quality that influences customer satisfaction. In addition the delight factor, proposed DSS implement AHP criteria weights for measuring the operational effectiveness. Only providing good customer service by itself is not enough cost effective. The goal is to enhance property values through active day-to-day management that focuses on maintaining high levels of occupancy and clients satisfaction, while lowering facility costs.

ANALYTICAL HIERARCHICAL PROCESS

AHP is a structured technique for handling complex decisions making. Rather than imposing a "best" solution, the AHP helps decision makers find one that structure of criteria priority suits best their goal and their understanding of the problem. It is a process of organizing decisions that people are already dealing with. AHP goal is to integrate different measures into single overall score for ranking decision alternatives. It uses pair wise comparison of chosen attributes. AHP allows executives to take into consideration both quantitative and qualitative measures and make trade-offs in between. The process initiates by structuring the decision problems in a hierarchy of criteria and then connecting the comparisons to get the weights of each criterion with respect to the goal. It is suitable when applying multi-focus strategy in large companies.

Value for a competitive index CI is calculate in different types of business groups such as prospectors, analyzers and defenders according to Miles and Snow organization types. The indexes have been calculated using normalized values of the main priorities Quality, Delivery, Cost and Flexibility respectively. The indexes are calculated as follows:

Prospectors:

$$\phi \sim 1-\{(1-Q\%^{\frac{1}{3}})(1-T\%)(1-C\%)\times F\%^{\frac{1}{3}}\}$$

Analysers:

$$\lambda \sim 1-\{(1-F\%)\times(ABS(\Delta Q*\Delta T*\Delta C))^{\frac{1}{3}}\}$$

Defender:

$$\varphi \sim 1-\{(1-C\%^{\frac{1}{3}})(1-T\%)(1-Q\%)\times F\%^{\frac{1}{3}}\}$$

DATA COLLECTION

Information about the company was collected from interviews, organized workshop for research method introduction and tutoring, approximately 25 questionnaires forms in the company to choose major critical factors, pair-wise comparison questionnaire conducted by the CEO, District manager and firm's financial statements to see how it reflects possible Business process orientation. After building up the empirical knowledge about corporate strategy the competitive priorities model was constructed using the AHP-Expert choice software. Main criteria were given weights considering two situations-before and after crisis to study the effect of the economic environment on the decision making process.

RESULTS

Results of questionnaires were analysed by AHP software "Expert choice". CI values and CFI were calculated according to the methodology formulas developed and presented in the

Industrial Management department of the University of Vaasa. They represent assessment of the multi-focused decision making process inside the company and the Sense and Response methodology evaluating critical factor values in particular.

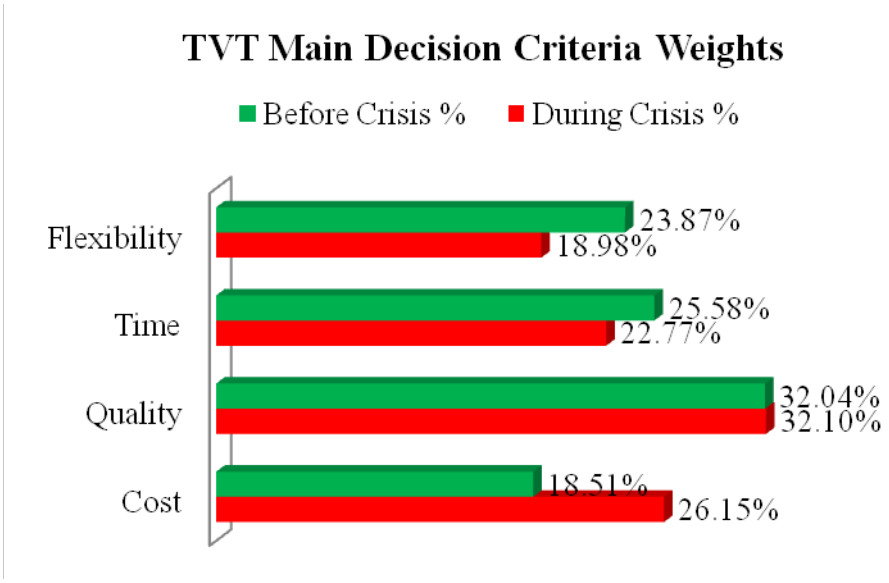


Figure 3: Main criteria weight results.

Main criteria values shows that the quality focus remains the most important criteria's for successful business, cost, timeliness and flexibility expanded their importance. The company more and more needs to achieve its quality goals in especially cost oriented manner. Flexibility priority takes the blow in the housing crisis situation and end up as the least important variable. Before crisis flexibility value turns out to be higher than expected. High level of flexibility is needed in companies looking for new markets or market share growth. Flexibility is a core competitive advantage in improvement of added value for customer and redesign of business cycle. The increase of market share is not a priority for TVT, neither in Turku or other areas. In this context from the high flexibility results TVT is unnecessary loosing resources, efforts and profit. As housing market is capital intensive business with long life cycle of products the company will not put itself at risk, as the business entrance barrier is high.

We calculate a numeric value for a competitive index in different types of business groups such as prospectors, analyzers and defenders according to Miles and Snow organization types.

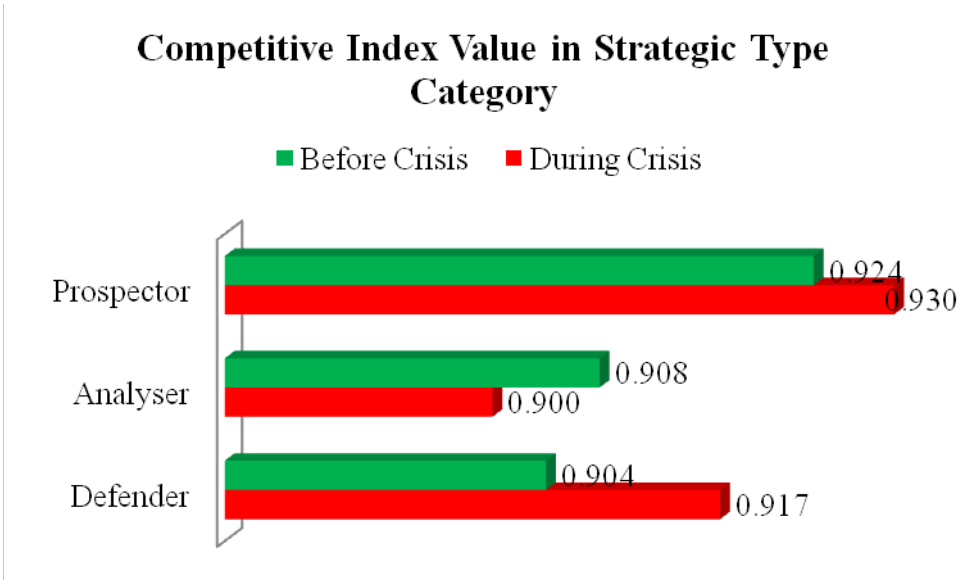


Figure 4: TVT Competitive index results.

From these results TVT performs as a prospector type of company in the segment of social housing market. Finnish Government offers direct subsidy supports for persons with economic issues, health problems, immigrants, unemployed, bad credit histories, which have low to no chance to be accepted as customers for the private home rentals. State authorities also give indirect credit guaranties to cap the interest rate to 3,4% on real estate properties offered to these individuals. This market niche is a 40% of the TVT clients. In this sense it is unique service function fitting.

Defender type of strategy is limited to cost competition. While TVT is keen on keeping its main customer group, price sensitive clients, it also possible to increase profit margin by adopting analyser features in segments like family and luxury, city centre wooden houses. By adding additional competition issues in the core competence portfolio, TVT services are moved up from continuous improvement to mass customization concept.

Customer Delight may be the difference between success and failure during turbulent times. It creates the additional clients attractiveness that one can't place a momentary value to. This exploratory study provides traffic light system for identifying critical factors that have to be taken care of immediately. After calculating series of indices, the results are generalized in the CFI index. It is also a basis for benchmarking of prioritization of factors in the business.

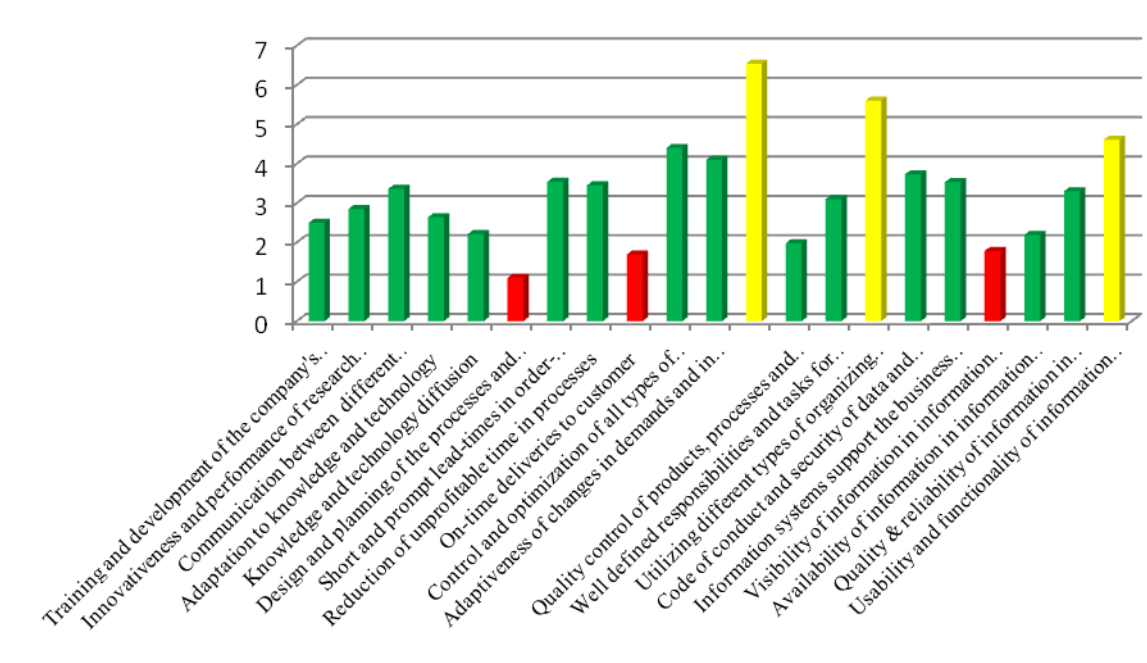


Figure 5: CFI index results.

CONCLUSIONS

Major competition issues in housing markets are price, location, size, condition and security. TVT performs as a defender type of company in the regular housing market, being price competitive to private housing organizations. Due to the government support system TVT can reallocate profit to keep low rental price level. Housing and real estate overall is capital intensive business, which translates to interest rate variation having high impact on rents. Government support system limits the effect of interest volatility to prices.

Time gap between tenants is one big loss generator. Streamlining this process with maintenance counterparts decreases vacancies rate. The housing management function is divided between company own unit and outsourced to outside companies. According to customer, the service provided by the own unit is valued higher by tenants. Cost analysis showed that the outside companies are more expensive than own work.

At the same time, advanced service segmentation between the different customer groups and optimal process design to reach the delight experience was pinpointed as the best option for profit increase.

TVT aim is to keep strong position in Prospector type of company in social housing market. It has a strong core competence operating in this market area without any competitors. This strategic advantage can be exploited in various ways. Pricing can be increased with the value of the administrative work done inside TVT, and by additional standardization of the whole service process.

The benefits of a fast and comprehensive method to gather important information in order to make resource allocation decisions at operational level are self-evident. Property fund

managers should be active - 'doing well by doing good' and as technology costs fall and energy costs rise, more and actions are economic driven. So improvement in the customer satisfaction can be seen as "low cost-high impact" action to combat lower rental growth, faster depreciation and higher risk premium, leading to higher yields and lower values over time. The benefits of our proposed DSS can be summarised as lower maintenance cost with efficient work order and preventative maintenance execution Reduce administrative costs by harmonizing lease execution and optimizing space utilization. Businesses that can effectively manage utilization and costs associated with real estate assets stand to reap substantial benefits. A complete, integrated strategy of all critical business functions is the foundation for effective real estate management.

However there is still the need of further development and therefore should be tested in future case studies. CFI can be utilized to test internal as well as external processes, based either on expectations and experiences of employees, customers or business partners.

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FRAMEWORK FOR STRATEGIC TECHNOLOGY MANAGEMENT IN HIGH-TECHNOLOGY ENTERPRISE CONTEXT

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ABSTRACT

Strategic technology management is an important practice for enterprises in an increasingly complex economic and social environment. In technology-based global competition advancements of technology proliferate rapidly. Companies have to manage their technological capabilities for business model development, product innovations, and for maintaining their productivity and competitiveness.

Entire field of strategic technology management is ambiguous and literature on theoretical frameworks is diverse. Practitioners in companies are lacking a comprehensive frame of reference for strategic technology management. In this paper a framework is discovered to describe elements of strategic technology management in high-technology enterprise context.

The framework is developed based on literature findings and by obtaining qualitative information on enterprise practices. The empirical research was conducted in 2008 – 2009 in the context of 45 large and small to medium-sized high-technology product companies and involved some 70 informants. Mainly abductive reasoning is used to infer explanation for the framework. Integrated management theory is applied to consider technology management in strategic dimension, categorized as structures, objectives and impacts.

Strategic management, organizational management, and technology management concepts are united in the framework as the main theoretical contribution. The paper provisions an outline to assist practitioners in definition and development of the practices in enterprises. As managerial implication, it is suggested that companies should consider establishing strategic technology management as an own managerial function amongst other organizational management disciplines.

In summary, the framework provides for scholars and practitioners a logically structured framework for strategic technology management.

Keywords: Strategic management, technology management, framework, MoT, technology management framework, enterprise, enterprise development.

INTRODUCTION

In technology-based global competitive environment companies have to manage their technological capabilities to maintain their competitiveness. Strategic technology management is an important practice for enterprises in an increasingly complex economic and social environment. The field of strategic technology management is related to several management disciplines, and literature on theoretical frameworks is diverse (see e.g. Khalil, 2000; Tidd, 2001; Phaal et al., 2004; Pilkington & Teichert, 2006; Cetindamar et al., 2009). For practitioners in companies *the problem is that there is no comprehensive frame of reference for strategic technology management*. In this paper a framework for strategic technology management in high-technology enterprise context is synthesized from based on findings from four individual research phases. The research question is:

RQ What are the elements of strategic technology management in high-technology enterprise context?

The framework was developed during 2008-2009 based on literature findings and by obtaining qualitative information on enterprise practices. The empirical research was conducted in the context of 45 large and small to medium-sized high-technology product companies. In the interviews and workshops some 70 experiences informants who knew the topic well were involved for structures and impacts category study, and technology management decision making material from a large company was used to gather information for the objectives category. Mainly abductive reasoning was used to derive some 250 classes and sub-classes for the 18 main elements of the framework. Integrated management theory of Bleicher (2004) was applied to consider technology management in strategic dimension categorized as structures, objectives and impacts. For each of the category a complete research phase was conducted, the results were documented and an article was written. In each of the articles the research process is presented and discussed in detail. The overview of the research proceeding is presented in Figure 1. The 5th research phase is in the scope of this paper.

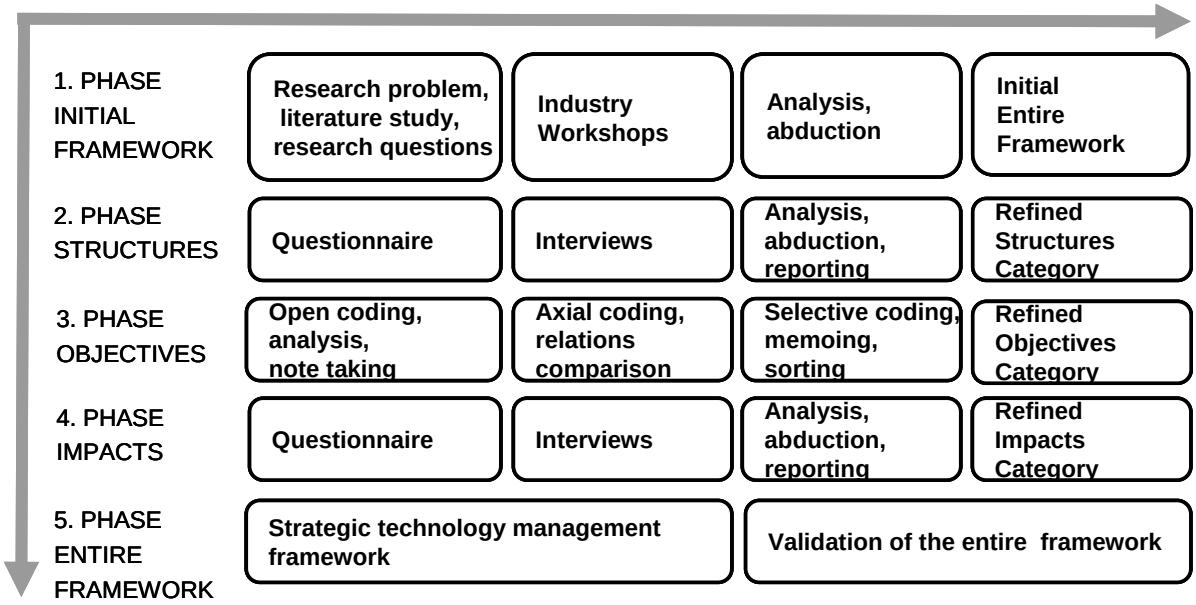

Figure 1: Proceeding of the research.

TYPES OF TECHNOLOGY MANAGEMENT FRAMEWORKS

Linking business to technology is a managerial challenge in enterprises. Strategic technology management is assumed to provide a solution to manage complexity caused by technology in dynamic environment (e.g. Burgelman et al., 2001; Dodgson et al., 2008). Technology management is often conducted as part of R&D management or innovation management (Drejer, 1997; Edler et al.; 2002, Tidd, 2001). Drejer (1997) have described four schools of technology management that emphasize R&D management, innovation management, technology planning or strategic technology management. According to Edler et al. (2002) so called 4th generation R&D management sees R&D and technology as strategic instruments for competitiveness and innovations, and emphasizes formulation of explicit technology strategy and integration of technology with business strategy. Current themes in R&D management are open innovation, networked R&D and knowledge management (Chesbrough, 2006; Lichtenthaler, 2008). In innovation management school the emphasis is on anticipation of technological changes and incubation of innovative products for commercialization, whereas in technology planning school the scope is to manage technology across the company using specific management methods like road mapping and portfolio management (e.g. Cooper et al., 1998; Tidd, 2001). Strategic technology management school combines technology and business aspects through management of technology activities (e.g. Drejer, 2004; Phaal et al., 2004; Lichtenthaler, 2008).

Positioning of strategic technology management is difficult due to the intertwined nature of technology in enterprise management. Multiple theoretical and practical frameworks for describing elements of technology management have evolved, but still the entire field is confusing and boundaries of concepts are blurred, and there are no commonly accepted frameworks (Phaal et al., 2004; Brent and Pretorius, 2008; Cetindamar et al., 2009). In table 1 is presented main types of technology management frameworks. Each of the framework types emphasize particular aspects of technology management i.e. processes, routines, methodology, need to integrate technology management with core business and strategic processes, or technology management as management of knowledge flows. Integrated management approach introduced by Tschirky (1991) sees technology management as a task of general management and divides the tasks into normative, strategic and operative dimensions.

Table 1: Main types of technology management frameworks.

Technology management framework type	**Example reference**
Generic process model	Gregory,1995; Cetindamar et al. 2009
Technology management functions	Kropsu-Vehkaperä et al. 2009
Technology management routines	Levin and Barnard 2008
Technology strategy approach	Burgelman et al. 2001
Innovation funnel	Wheelwright and Clark 1992
Knowledge management	Nonaka 1995
Methods and tools approach	See e.g. Phaal et al. 2006
Integration into core business processes	Metz 1996; Phaal et al. 2004
Integrated management concept	Tschirky 1991

FRAMEWORK FOR STRATEGIC TECHNOLOGY MANAGEMENT

For the framework development concepts from strategic management, technology management and organizational management theories are used. The essential concepts and key references are presented in dissertation of the author. From strategic management perspective the role of technology in value creation, business model definition and as a source of productivity is emphasized. Moreover, technological capabilities affect on company's success in formulation and execution of company's business strategy. In external socio-economic context technology has a major impact for sustained development and wealth creation. For the framework creation integrated management concept is used as the basis from organizational management theories. (Sahlman and Haapasalo, 2009a; Sahlman, 2010)

Elements of strategic technology management are described in strategic dimension in three categories: *structures, objectives and impacts*. The framework is a reference model that describes the categories, their main elements and contents to provide viewpoints on strategic technology management. The strategic technology management framework is presented in Figure 2.

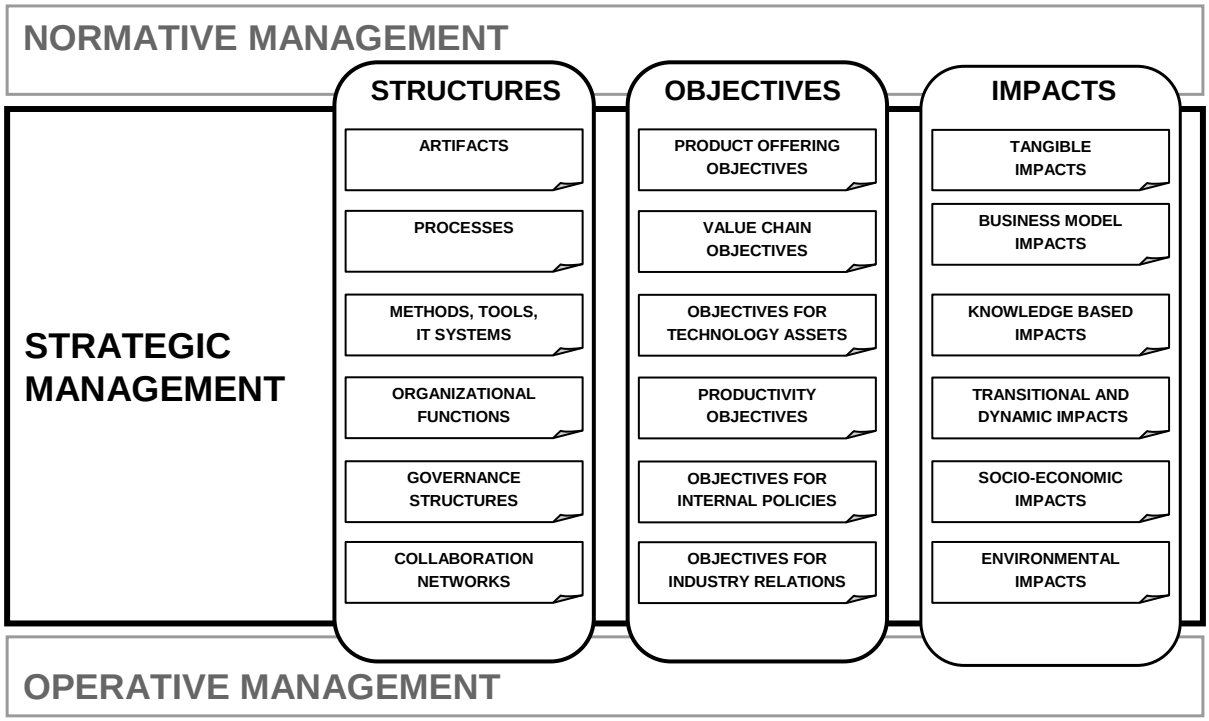

Figure 2: Strategic technology management framework (Sahlman, 2010; published by permission of ACTA Universitatis Ouluensis)

Structures category of the framework

The *structures* category contains the main classes of artifacts; processes; methods, tools and IT systems; governance; organizational functions and collaboration networks. The category contains a logical process view to a company considering methods, tools and IT systems that

are needed to produce artifacts by procedures and practices. The operative work is governed and performed by organizational functions that are making decisions and managing the activities. Furthermore collaborative networks represent stakeholders that are involved in the activities and form a part of the technology infrastructure for the company. The *structures* category of the framework is presented in Table 2.

Table 2: Structures category of strategic technology management framework (Sahlman and Haapasalo 2009b, published by permission of PICMET conference organization).

Main element	Definition
ARTIFACTS	Information, documents, reports, plans, prescriptions as the outcomes of the performed processes of technology management.
PROCESSES	Procedures and practices performed to transform inputs into artifacts of technology management.
METHODS, TOOLS, IT SYSTEMS	Techniques and tools to perform tasks of the procedures and practices of technology management. Information systems for processing and storing artifacts generated in the processes of technology management.
GOVERNANCE	Management structure, definition of authorization and policies for decision-making of technology management topics.
ORGANIZATIONAL FUNCTIONS	Managerial disciplines of an organization for planning, organizing, leading and monitoring technology management functions.
COLLABORATION NETWORKS	Stakeholder organizations involved in the company's processes of technology management.

Objectives category of the framework

The *objectives* category's main elements consist of product offering, value chain, technology assets, productivity, internal policies and industry relations. The *objectives* category of the framework is presented in Table 3.

Table 3: Objectives category of strategic technology management framework (Sahlman and Haapasalo, 2011b, published by permission of Inderscience).

Main element	Definition
PRODUCT OFFERING	Objectives for product offering enabled by technology e.g. cost, performance, capacity, quality, reliability, availability, maintainability, and commonality.
VALUE CHAIN	Value chain related objectives for technology supply e.g. business scope and scale of technology use, position in value chain, revenue logic, supplier lock-in, technology change cost.
TECHNOLOGY ASSETS	Objectives for technology assets e.g. scope, scale of deployment, lead time for products, life-cycle state, performance, and compliancy to internal and external standards.
PRODUCTIVITY	Objectives for productivity enabled by technology e.g. technology portfolio scope and scale, life-cycle position, operating expenses, capital expenses, scope and scale of competence and resources to develop and maintain the technology base.
INTERNAL POLICIES	Objectives for internal policies, standards, processes and practices e.g. policies and internal standards definition and deployment, best practices dissemination, harmonization of practices, agility and adaptability of technology creation.
INDUSTRY RELATIONS	Objectives for industry relations e.g. compliancy to regulations, standards, de-facto standards, standardization strategy and policy, IPR, licensing, supplier strategy, extend of supplier base, publications, collaboration with institutes, creation and support of technology ecosystems.

Properties of product technologies must satisfy qualitatively and quantitatively the product offering objectives of a company. Company's business model defines technology related objectives concerning revenue logic, business scope and scale, value chain aspects and supplier base. For example technology selections affect on potential technology supply, supplier lock-in and change costs. Furthermore decisions and objectives on technology assets' lifecycle, proprietary ness, standards compliancy, scope and scale reflect product offering targets and aspects of value chain objectives. Technology asset base determines also productivity of a company in terms of product development speed, cost, competence and resource needs, and lifetime costs due reusability and maintainability. Productivity is influenced by existence of internal policies, commonality of operational processes and practices, and agility of technology creation and use enabled by technology. Also objectives for industry relations concerning standardization, regulation, intellectual property management and collaboration with industry eco-systems, suppliers, competitors and institutes are needed.

Impacts category of the framework

In the *impacts* category the main elements are tangible outcomes, business model, knowledge based, transitional and dynamic, socio-economic and environmental impacts. The *impacts* category of the framework is presented in Table 4.

Technology embedded in products and services cause tangible impacts when delivered by a company. Management of technology has a significant consequential effect on the company's business model which is enabled by technology, investments and position of the company in value chains and industry eco-systems. A company also creates and accumulates knowledge through its activities that are directed by strategic technology management. On the other hand tangible outcomes and company's business model cause impacts in the market place, diffusion of innovations, technology and industry evolution which can be observed over technology lifecycles and trajectories. Finally, technology management causes social, economic and environmental impacts through utilization of technology in tangible outcomes.

Table 4: Impacts category of strategic technology management framework (Sahlman and Haapasalo 2011a, published by permission of Inderscience).

Main element	Definition
TANGIBLE OUTCOMES	Impacts of technology management by technology manifested in delivered products and services.
BUSINESS MODEL IMPACTS	Impacts of technology management to the company's offering, value creation system, industry clusters, revenue logic, value creation and productivity.
KNOWLEDGE BASED IMPACTS	Impacts of technology management on skills, competence, data, information, knowledge and wisdom embodied in people and enterprise capabilities.
TRANSITIONAL AND DYNAMIC IMPACTS	Impacts of technology management that can be observed as phenomena in the market and environment.
SOCIO-ECONOMIC IMPACTS	Impacts of technology management on social welfare and people's behavior.
ENVIRONMENTAL IMPACTS	Impacts of technology management to natural resources consumption, materials exploitation and waste.

Validation of the framework

The entire framework was validated after completion of the categories by interviewing five experienced industry practitioners who all had at least 25 years of experience in high-technology companies. The validation was conducted as evaluation of the relevance and current state of the framework elements in scale from 1 to 10. Evaluation results are presented in Appendix 1.

Relevance of the elements was evaluated on average from 8.0 to 9.4. Methods, tools and IT systems element scored 7.0 being seen as least relevant in structures category, and socio-economic and environmental impacts in impacts category scored 7.2 and 6.0. Nevertheless methods and tools were stated to be relevant in large companies and role socio-economic and environmental impacts were seen to be increasing. The current state of the elements was evaluated by the interviewees on average from 6.2 to 7.6 indicating that the practices are not systematic in companies, especially artifacts element in structures category scored 5.2. Collaboration networks got the highest score at 8.0, reflecting the necessity of networked mode of operation in global high-technology companies.

On average all the elements were seen relevant and their substance was understood by the interviewees. They also were able to associate and link the elements with business management and enterprise strategy. Interviewees stated that it is important to see the whole picture related to strategic technology management for which the framework was seen to provide a logical structure. Also positioning technology management in strategic dimension was seen right. Distinguishing strategic technology management clearly from R&D management was seen beneficial to improve visibility to technology matters, decision making and to technology strategy execution.

THEORETICAL CONTRIBUTION

The research problem i.e. lack of comprehensive frame of reference for strategic technology management was approached by developing a conceptual framework that describes the elements of strategic technology management in strategic dimension. The main theoretical contribution of this paper is the synthesized logical framework model for strategic technology management. Thus, knowledge of strategic technology management school (see Drejer, 2004; Phaal et al., 2004; Lichtenthaler, 2008) is enhanced.

The framework is built on the integrated management theory of Bleicher (2004) and enhances previous technology management models (e.g. Gregory, 1995; Luggen and Tschirky, 1991) that are typically focusing on specific aspects of technology management like processes, functions, routines or methods and tools (see Table 1). In the framework, Gregory's (1995) five process model, *identification, selection, acquisition, exploitation, protection*, is suggested to be enhanced by *strategic planning, technology development* and *technology disposal*. Cetindamar et al. (2009) suggests that *learning* should also be included in the process framework for technology management.

In addition, contemporary thinking on challenges of strategy execution high lights management of strategic initiatives and objective setting for organizational entities (e.g.

Kaplan and Norton, 2005; Mankins and Steele, 2006). Instead, for applying the framework, transformation of business objectives into strategic objectives for technology is proposed. The framework also connects aspects of the company's internal and external influence of strategic technology management with socio-economic environment.

For the creation of the framework, organizational management, technology management and strategic management theories were applied. The framework unites socio-economic and environmental context with enterprise management concerning technology aspects, which is useful for theoretical consideration of technology management as an own managerial discipline in a multifunctional organization.

MANAGERIAL IMPLICATIONS

The purpose of this research was to outline a conceptual framework on strategic technology management to assist practitioners in definition and development of the practices in enterprises. The substance of the framework is reflecting conceptions of scholars and practitioners in the field. The framework presents essential topics, viewpoints and interrelations of strategic technology management issues in enterprises. It also considers technology management in larger socio-economic context, thus increasing awareness of the impacts of strategic technology management.

Enterprises should consider technology management as an own managerial discipline in strategic dimension together with e.g. business and product portfolio management. Typically technology management is seen as an implicit function, most often embedded in R&D management. For the purpose of developing strategic technology management as an explicit practice the framework provides a frame of reference for the necessary structures i.e. artifacts, processes, methods, organizational functions and governance, and collaboration networks.

The framework also highlights importance of strategic objectives setting for technology. Typically, strategic objectives are related to business topics and they are targeted for organizational functions and activities, market positioning and key performance indicators of the business. Instead, strategic technology management objectives should be directed on properties and attributes of technologies used in a company. Therefore a transformation of business objectives to technology objectives is needed through strategic technology management activities. In this respect, the main considerations are related to managing technology over product life-cycles and assessing technology gaps versus business objectives. Thus creation, deployment, maintenance, reconfiguration and fusion of technological capabilities of a firm are in the focus as industries, markets, products and technologies evolve over time.

Along the logic of the framework model, the objectives of strategic technology management to technology are related to product offering, value chain, technology assets, productivity, internal policies and industry relations. When the objectives are realized in industry and socio-economic context of the company through structures and operational activities, the activities influence on technology infrastructure of the company and create external impacts and have an influence on technological capabilities. Consequently, the generated

capabilities and impacts cause technology and industry evolution, and creates wealth and social change.

The developed framework is intended to assist practitioners for identification, discussion, communication and presentation the complex managerial field of strategic technology management.

CONCLUSIONS

In this paper, the results of the four research phases are concluded as synthesized framework for strategic technology management in high-technology enterprise context. In an increasingly complex and dynamic environment practitioners in enterprises are facing a challenge how to strategically manage technology to sustain the company's competitiveness. While companies have evolved to multifunctional strategic orientation where technology has a significant role, there still is no comprehensive frame of reference for strategic technology management. The synthesized framework for strategic technology management answers to the **RQ** 'What are the elements of strategic technology management in high-technology enterprise context'.

The research was conducted in large and small to medium-sized enterprise high-technology enterprise context. The framework was developed based on literature findings and using questionnaires and documents to acquire data for analysis and abductive reasoning to describe a possible solution to the research problem. The entire framework was validated by interviewing experienced practitioners in high-technology companies.

The framework for strategic technology management consist categories of *structures, objectives* and *impacts* in strategic dimension. The categories are formed from six main elements each containing several sub-classes.

The main theoretical contribution of the research is the framework that provides a logical structure to elements of strategic technology management. The framework unites strategic management, organizational management and technology management viewpoints to enterprise management, and enhances knowledge in strategic technology management.

As the main managerial implication it is proposed that companies should define systematic practices for strategic technology management, and integrate it with other managerial disciplines as an own managerial function. For practitioners the framework provides a frame of reference for conceptualization and organizational development of strategic technology management.

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APPENDIX 1 Framework validation results

Table 1: Evaluation results of the framework validation: relevance of the element. Scale for evaluation: Not relevant 1, extremely relevant 10.

ELEMENT	Evaluation results					Average
Structures						
Artifacts	9	6	8	10	8	8.2
Processes	8	7	10	9	9	8.6
Methods, tools, IT systems	3	8	8	8	8	7.0
Governance	8	9	9	10	8	8.8
Organizational functions	8	8	10	10	9	9.0
Collaboration networks	9	10	10	10	8	9.4
Objectives						
Product offering	9	10	9	10	9	9.4
Value chain	9	10	2	10	9	8.0
Technology assets	9	9	9	9	9	9.0
Productivity	8	9	5	10	8	8.0
Internal policies	7	7	9	9	8	8.0
Industry relations	10	8	4	10	9	8.2
Impacts						
Tangible outcomes	5	10	10	8	10	8.6
Business model impacts	9	8	9	10	8	8.8
Knowledge based impacts	9	7	9	10	8	8.6
Transitional and dynamic impacts	9	9	6	10	8	8.4
Socio-economic impacts	3	10	7	10	6	7.2
Environmental impacts	2	10	1	10	7	6.0

Table 2: Evaluation results of the framework validation: current state of practice. Scale for evaluation: Not established 1 - Well established 10.

ELEMENT	Evaluation results					Average
Structures						
Artifacts	5	6	3	7	6	5.4
Processes	5	7	7	5	7	6.2
Methods, tools, IT systems	9	8	8	6	5	7.2
Governance	8	7	10	7	6	7.6
Organizational functions	8	8	8	6	8	7.6
Collaboration networks	8	9	10	6	7	8.0
Objectives						
Product offering	6	8	8	7	8	7.4
Value chain	9	8	1	7	7	6.4
Technology assets	7	8	8	7	6	7.2
Productivity	6	8	5	8	7	6.8
Internal policies	4	7	8	7	6	6.4
Industry relations	8	8	5	8	8	7.4
Impacts						
Tangible outcomes	8	7	8	8	7	7.6
Business model impacts	9	8	9	6	6	7.6
Knowledge based impacts	7	7	7	8	6	7.0
Transitional and dynamic impacts	5	7	6	7	6	6.2
Socio-economic impacts	5	8	7	6	6	6.4
Environmental impacts	9	8	2	8	7	6.8

H3 – Organizational-management perspectives

H3.1 **Exploring the merger & acquisition strategies for bio-tech industry**
Yen-Ku Kuo

H3.2 **Constructing information ethics indicators for Taiwan's corporations**
I-Chuan Chen

H3.3 **Technology and management innovation in public-private partnerships: A new win-win-win model for the Hong Kong police force**
Ir. Jolly Wong

H3.4 **The inverted U-shaped relationship between business unit's slack and performance: The case of Indonesia**
Dr. Fuad Fuad

EXPLORING THE MERGER & ACQUISITION STRATEGIES FOR BIO-TECH INDUSTRY

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ABSTRACT

In the globalization and competition situation, merger and acquisition become a popular way to acquire technology and realize enterprise expansion. However, most merger and acquisition evaluations focus on finance indices, but few studies explored production efficiency of technology-oriented business in fast changeable environment. This study proposed an effective method to assist bio-tech industries to evaluate the production efficiency and find the candidate priority of merger and acquisition under the price of merger and acquisition. To do this, we develop an approach by combining with Data Envelopment Analysis and heuristic technique to efficiently find the merger and acquisition candidate in complicatedly technology conditions. Numerical exercises based on U.S. 11 bio-tech industry realistic data are conducted. We selected the capital expenditure, the sum of employees and R & D expense as input variables, and the net income and the patent value as output variables in 2008. The results demonstrate that our method can help the bio-tech companies effective explore the best efficient candidates of merger and acquisition to expand their business strategy. Moreover, this method can help firms in simulating the results to predict the success of future merger and acquisition.

Keywords: Merger and Acquisition; Efficiency evaluation; Data Envelopment Analysis; Candidate

INTRODUCTION

Over the last decades, because of the globalization and information circulation, business merger and acquisition (M&A) has emerged as important. Therefore, many businesses try to adjust their developmental strategies to cope with the global economic changes by M&A. M&A refers to the process of merging or acquiring all or parts of other companies' property rights under certain conditions in order to have the controlling rights (Song and Chu, 2006).

In fact, business M&A seems to be the best way for industries to maintain their competitive edge in today's competitive market and for businesses achieve reinvigorate their vitality, providing for a sustainable existence (Cristina et al., 2010). Hence, M&A is a convenient method for hastening business growth (King, Slotegraaf, and Kesner, 2008; Louis and Harjeet, 2008; Hagedoorn and Duysters, 2002). Generally speaking, the main strategy for business production is to reduce cost and increase output. A company can reach their strategic goal faster and at a lower cost through buying another company or integrating with another organization (Baars and Kemper, 2008; Myriam et al., 2006).

M&A has not only been considered as the quickest route for expansion, but it also changes the competitive environment by reducing the number of competitors in an industry (Santomero and Seater, 2000). Therefore, to increase the success of M&A activities, the critical step for a bidder company is to identify suitable target companies that have better synergy to those of the bidder company. It is the critical step of an M&A activity because an inappropriate selection likely leads to the failure of this M&A activity. To choose better candidate of M&A is also important from the perspective of possible target companies. Hence, this study proposes a prediction method that can decide the best candidate company of M&A. Such method will facilitate companies to develop appropriate strategies for improving their possibility of M&A and increasing economic benefits from future M&A activities.

Bio-tech industry is an industry based on knowledge and intensive technology, which invests a high proportion of R & D in investment. The products in a high tech industry are high-risk and can yield large profits (Lee, Yang, Chen and Chen, 2010; Vanderbyl and Kobelak, 2007). Bio-tech industry generally fluctuates rapidly, but has huge market and economic influences on other industries (Coombs, Mudambi and Deeds, 2006; Michael and Shankar, 2009; Tsai and Erickson, 2006). Thus, in the U.S., industries keep their dominant economic position in the world. We take well-known enterprises in U.S. bio-tech industry as research targets to explore its optimal candidate through M&A.

In the bio-tech industry, patent data is the most representative indicator in research and development capabilities. Previously, patent data has been used for quantifying and understanding the process of technological development, and evaluating its relationship to innovation performance in various countries, regions and companies (Verbeek and Debackere, 2006). The creation of patents, which is the major output of research and development, could capture innovation that is the result of knowledge transfer and organizational learning through inter-firm R&D agreements (Li et al., 2009; Franz and Patrick, 2009). Furthermore, patents have received so much attention as the most important output indicators of innovation activities because they contain standardized and detailed

information as well as being continuously available across time (Andrea and Josep, 2008; Lee et al., 2009; Deepak, 2008). In addition, patent analysis is the only formally and publicly verified output measure that can empirically explain most aspects of inventive activities in developed countries (Ma and Lee, 2008; Cong and Tong, 2008). Therefore, patents and patent analysis are nowadays widely used as the measures of innovation and inventive activities. There are many indicators representing the strength of patent data, and among them, we chose the patent value as the output of DEA. Patent value should indicate a firm's inventive prowess, and should reduce capital costs as they inform external investors' about the abilities of the firm to successfully engage in the invention process, as well as the likelihood of achieving cash flows from the technology. Thus, the efficiency value through DEA is more representative for the actual R & D status of a bio-tech industry. Moreover, we use the multiple efficient frontiers to determine different level group of the efficiency, and each level represented the difference of goodwill, which can determine the M&A price. In addition, the sensitivity of DEA (Jahanshahloo et al., 2005; Sharma and Thomas, 2008) is used to get the policy of the most efficient candidate.

The rest of the paper is organized as follows: Section 2 develops the construction of the choosing candidate method. Section 3 describes the data and empirical methods used. Finally, Section 4 presents concluding remarks.

CONSTRUCTION OF OPTIMUM CANDIDATE METHOD

The multiple production efficient frontiers

The relative efficiency value of Decision Making Unit (DMU) can be divided into four levels: super- efficient units, the efficient edge units, the non-efficient edge units, and significant non-efficient units (Norman and Stocker, 1991; James, 2009). We use the selection methods of multiple production efficient frontiers (Mithun and Song, 2009) to rank the non-efficient units to reduce time for unnecessary integration status in our model.

The selected method of multiple efficient frontiers is to remove the units of super-efficient frontier from all units, and re-rank second efficient frontier from the non-efficient units. And it would continue until the number of non-efficient frontier units is smaller than the number of input variables＋number of output variables / 2.

Sensitivity Analysis

This study mainly explored the M&A price by the sensitive of post-M&A efficiency, which get changes in a single variable. Therefore, this section describes the sensitivity analysis of DEA

(Adler et al., 2002; Valter, 2006; Jie et al., 2009).

Sensitivity analysis discovers how the changes in input and output variables influence the relative efficiency value. In brief, sensitivity analysis means that "reducing the output will reduce efficiency of the target unit, however, to what extent the output reduce, the target unit can still maintain efficiency = 1. The post-M&A efficiency may be efficient or non-efficient. If non- efficient, we can change the input to be smaller or output to be larger, and can get the sensitivity of single variable for achieving efficient. Otherwise, if efficient, this study will use the sensitivity analysis of data excluding method (Andersen and Petersen, 1993) to get the efficiency value that be greater than 1, which can be adjusted to go back to efficiency =1. Hence, we can get the sensitivity of single variable.

The Optimum Candidate Method

This study focuses on a specific company executing the horizontal M&A. The decision of selecting candidate is based on remaining efficient after M&A, therefore, this study uses M&A price as the key point. In brief, M&A must pay the price, which will increase the company's capital expenditure might affect its efficiency after M&A. Therefore, this study explores how much the M&A price is, which still allows post- M&A's company to maintain efficient. Moreover, we can get the relative M&A price of each candidate using the way of multiple production efficient frontiers, and obtain the ratio, which can get better candidate. Hence, this study proposes the optimum candidate method, and better candidate using relative ratio, as following:

Relative ratio = relative price/price of variables maintaining (promoting) efficient

SAMPLE STUDY

Sample and patent data

The sample of this study selected 11 bio-tech companies in U.S. We selected capital expenditures, sum of employees, and R & D expenses in 2008 as input variables, and net income and patent value in 2008 as output variables. This study constructs the data set from two databases: Standard & Poor's (S&P) COMPUSTAT database and United States Patent and Trademark Office (USPTO) database. We collected data on capital expenditures, sum of employees, and R & D expenses from the COMPUSTAT database. These data are shown in Table 1.

Table 1: Data of input and output.

	Input			Output	
	Capital Expenditure (millions of dollars)	Employees (thousands)	R&D Expense (millions of dollars)	Net Income (millions of dollars)	Patent Value
DMU	I(x1)	I(x2)	I(x3)	O(y1)	O(y2)
Abbott Laboratories (A)	1287.724	69.000	2786.067	6917.719	222.7427
Amgen Inc (B)	672.000	16.900	3030.000	6233.000	123.5981
Bristol-Myers Squibb Co (C)	941.000	35.000	3617.000	7284.000	650.6048
Cardinal Health Inc (D)	376.100	47.600	152.900	3337.600	23.53819
Johnson &Johnson (E)	3066.000	118.700	7758.000	14986.000	108.5411
Kimberly-Clark Corp (F)	906.000	53.000	297.000	3727.000	698.2427
Merck & Co (G)	1298.300	55.200	4805.300	9845.400	406.6093
Monsanto Co (H)	918.000	26.400	1144.000	4061.000	633.5535
Pfizer Inc (I)	1701.000	81.800	8578.000	10141.000	415.3648
Schering-Plough (J)	747.000	51.000	3529.000	3940.000	2.333333
Wyeth (K)	1408.999	47.426	3373.213	6454.833	249.8254

Implementation procedure of method and the result

After collecting data, we began the process of choosing candidate in 11 bio-tech firms using the optimum candidate method. Since choosing the candidate, from 11 bio-tech companies, this study randomly selected a company that would merger other company. Therefore, we would select Kimberly-Clark Corp (F) that assumed M&A's motive as the target company. First, we must carry out the multiple production efficient frontiers to determine the levels of different efficiency. Therefore, we got the first and the last efficient frontiers using multiple efficient frontiers as shown in Table 2. From this, we discovered that the first efficient frontier were B, C, D, F and H, and G and A were the second efficient frontier, and the third efficient frontier were K, E and I, and J was the last efficient frontier. Each DMU of same level both represented the same goodwill, which was a basis of M&A price for mergering different candidates. Moreover, this study would use the difference goodwill as the basic of M&A's price, called the relative price. Therefore, the relative price is that the capital expenditure of candidate multiplied by its coefficient of efficiency level that is 1, 0.95, 0.9 or 0.85. For example, if A was acquired, its relative price was 1223.3378 (=1287.724*0.95).

Table 2: multiple efficient frontiers before M&A.

First			Second			Third			Fourth		
Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score	Rank	DMU	Score
1	**B**	1									
1	**C**	1									
1	**D**	1									
1	**F**	1									
1	**H**	1									
6	G	0.880489	2	**G**	1						
7	A	0.735097	2	**A**	1						
8	K	0.705487	8	K	0.89713	3	**K**	1			
9	E	0.698005	9	E	0.88873	3	**E**	1			
10	I	0.681505	10	I	0.78617	3	**I**	1			
11	J	0.568653	11	J	0.69553	11	J	0.905393	4	**J**	1

The target company, F, respectively carried out M&A with other 10 companies and got the post-M&A's efficiency as shown in Table 3. From this, we discovered that the efficient DMUs were F+B, F+C, F+D and F+H, and others combinations were the non-efficient DMUs. Therefore, we can explore the difference situation with efficient and non-efficient. We can get the sensitivity of capital expenditure of individual candidate, which was the price of maintaining efficient. Then, we could get the relative ratio according to the optimum candidate method as shown in Table 4. If post-M&A's efficiency was non-efficient, we could change the capital expenditure to be smaller and get the sensitivity of capital expenditure for achieving efficient as shown in Table 5. From Table 4, F can choose to merger D, because its relative ratio was smaller than others. If post-M&A's efficiency was non-efficient, F can choose to merger G, because its relative ratio was bigger than others.

Table 3: efficiency after M&A.

State	Efficiency
F+A	0.81860682
F+B	1
F+C	1
F+D	1
F+E	0.73307224
F+G	0.91804878
F+H	1
F+I	0.72310459
F+J	0.74295567
F+K	0.78637421

Table 4: Post-M&A's efficiency = 1.

State	relative price (capital expenditure * coefficient of level)	price of maintaining efficient	Relative ratio (relative price / price of maintaining efficient)
F+B	672	93.42	7.19332
F+C	941	321.7	2.92508
F+D	376.1	377.47	0.99637
F+H	918	456	2.01315

Table 5: Post-M&A's efficiency < 1.

State	relative price (capital expenditure * coefficient of level)	price of promoting efficient	Relative ratio (relative price / price of promoting efficient)
F+G	1233.385	246.68	5.00004
F+A	1223.337	466.71	2.62117
F+K	1268.099	621.15	2.04152
F+E	2759.400	1491.64	1.84991
F+I	1530.900	683.80	2.23880
F+J	634.950	537.64	1.18098

CONCLUSIONS

In the globalization and competition situation, M&A become a popular strategy for many bio-tech companies to extend their business roadmap, and companies usually conduct M&A to pursue complementarities from other companies for preserving and/or extending their competitive advantages. M&A is an important strategy within the enterprise but, and it cannot endure any decision-making mistake. In addition, appropriate selection of M&A candidates for a given bidder company is a critical first step to the success of the M&A activity. Therefore, this study provides an effective search for the most suitable candidate when a company implementing M&A, as well as the analysis of the operational efficiency after the forming of the M&A. We develop an approach by combining with DEA and heuristic technique to efficiently find the M&A candidate with the methods of multiple production efficient frontiers, the sensitivity analysis, and the optimum candidate method in complicatedly technology conditions. Its focuses are on the realization of operation efficiency and evaluate the capital expenditure.

According our proposed method, we can easily separate target candidates to different priority and assist bio-tech companies to evaluate the operation efficiency and find the candidate priority of M&A under different M&A's price. This method can help firms to simulate the M&A's results for planning future M&A. It also allows companies to choose the appropriate candidate for M&A, which can cause the post-M&A's firms to have the most stable efficient under a more reasonable M&A's price. More importantly, this application

design might help top managers for decision making in business extension.

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CONSTRUCTING INFORMATION ETHICS INDICATORS FOR TAIWAN'S CORPORATIONS

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ABSTRACT

As advancement in information technology makes work more efficient, computer and internet have become an essential tool for corporations. Information ethical issues has become the urgent topic of modern Corporations. In order to prevent staff's illegal or immoral behavior which may damage the corporation's image, implementation of information ethics policy should be more thoroughly considered.

The purpose of this study was to construct indicators of measuring corporate fulfillment of information ethics in Taiwan. This study reviewed related literatures and interviewed corporate executives and academic scholars to establish the structure of indicators. The indicators were organized into four categories, namely, corporate executives' cognition and supports in information ethics, information ethics policy, control mechanism on information ethics, and information ethics education.

Delphi method and Analytic Hierarchy Process (AHP) were employed to collect and analyze data in this study. The 13 panelists represented both academic scholars who have specialized in the field of information ethics and corporate executives who are responsible for information ethics policies. Three rounds of Delphi questionnaires surveys were first conducted to evaluate the adequacy of indicators. Based on the results of Delphi surveys, indicators were categorized into four purpose levels, 13 basic levels and 60 measuring items. Then, the AHP was used to calculate the weights of the indicators at both purpose and basic levels.

Finally, a reliable and valid tool for evaluating corporate practices on the information ethics was presented based on the findings of the study.

Keywords: Information ethics, corporate information ethics, indicators of information ethics

INTRODUCTION

The Executive Yuan of the Republic of China convened 26th technical consultant council in April, 2006. In the meeting, deliberation was made to make a preliminary decision “the Basic Law of High Quality Network Society”, hoping that through the ordinance to achieve the goal of the communication ethics, and then promote the development of information-related policies into a higher level of information society. In addition to construct the hardware of high-quality network society and to promote the application of the information-related services and industries, how to build "information ethics" has become one of the high-profile issues (iThome, 2007.）

World Summit on the Information Society (WSIS) in Geneva proposed that more people have come to recognize the need to prevent the misuse of information and communication technology based on society values. It pointed out that the establishment of information ethics is not only to enjoy the convenience of the information and communications technology, but to avoid possible negative effects and to promote positive values such as peace, freedom, equality, and solidarity awareness to wake the concepts of information ethics and moral connotations（iThome, 2007.）

According to the ETtoday reports in May 2007, As an e-mail fraud led the market value of Apple Inc. instantly evaporated in 2.8 billion U.S. dollars in just 6 minutes, at the same time, the stock price of Apple fell down 2%（ETtoday, 2007.）

From the above, it is believed that information technology is now widely integrated into business activities of a corporation's process. In this perspective, the company’s reputation and stakeholder’s equity are influenced directly by information ethics.

In order to prevent staffs’ illegal or immoral behavior which damages the corporation’s image, this study suggests that implementation of information ethics policy should be more fully considered. Therefore, this paper will construct the indicators which are concerned with the development and implementation of corporate information ethics. By using these indicators, managers can conduct self-inspection and refer to related information policies.

At present the related research about the corporate information ethics indicators is still rare and this paper will broaden the scope of information ethics. So the main research objectives of this study are as follows:

1. Review the related literature and results of case interviews to construct indicators of evaluating corporate information ethics.
2. Use the Delphi method to evaluate the indicators.
3. Provide practical reference indicators in the future when carrying out information ethics policies.

LITERATURE REVIEW

Information Ethics

The term of information ethics can be traced back to 1940, MIT Professor Norbert Wiener of computer studies, focusing on the computer ethics (Bynum, 2001). Owing to the advance of computer technology and internet, information can be effectively managed, utilized and transmitted, and that opened the ethical issues different from the past study. The so-called "information ethics", is to discuss the behavior of human use of information and is the question of right or wrong (Chuang, 1996). The scope of information ethics behaviors includes information collection, collation, use, storage and dissemination other than moral subject.

Facing the information era, Mason (1986) proposed four major ethical issues of information: information privacy (Privacy), information accuracy (Accuracy), intellectual property rights (Property) and information access (Accessibility). These summarized in an acronym – PAPA.

1. Information Privacy

What kind of individual or corporate information can a person reveal to others, under what conditions and with what safeguards? Which things can people keep as secrets and not be forced to reveal to others?

2. Accuracy

Who is responsible for the authenticity, fidelity and accuracy of information? Similarly, who is to be held accountable for errors in information and how is the injured party to be made whole?

3. Property

Who owns information? What are the fair prices for an exchange? Who owns the channels, especially the airways, through which information is transmitted? How to allocate scarce resource?

4. Accessibility

What information should one be required to divulge about one's self to others? Under which conditions? What information should one be able to keep strictly to one's self? These are some questions that related to privacy. Today more than ever cautious citizens must be asking these questions.

From the above information ethical issues, it is argued that information ethics has become a so important concept that is helpful to the advancement in moral connotations of applying information technology.

Corporate Cognition about Information Ethics

Traditional western philosophy holds that thinking comes before the motion (Liu, et al., 2004). Trevino (1986) believed that one's level of moral recognition, will affect his decision-making in the right/wrong judgment. So, people may make different decisions when they are at different stages of moral awareness. (Kohlberg, 1984)

Managers may enhance ethical behaviors within organizations through establishing and operating ethics policy (Hsu, 2005). The main purpose of ethics policy is to standardize the overall directions of ethics within organizations, and educate employee corporate ethics. Therefore, institutions, regulations, or approaches which can improve the quality of ethics in an organization are regarded as means of implementing ethics (Wu, et al., 2004; Hsu, 2005). Currently, there are many researches indicating that ethics rules are the solutions to ethical related issues among employees. And managers also deploy ethical rules as an appropriate approach to deal with ethical problems (Robin, et al., 1989).

Information ethics is in response to ethics issues arising from information technology. Information ethics education establishes the basis for information ethics literacy. Education can lead learners to change values and enhance ethical cognitive, and furthermore, emphasize the importance of information ethics issues (Wu, 2002). As well as to information system experts and managers, structural training courses can enhance sensitivity on the issues of information system and development (Heide & Hightower, 1983; Lin,, et al., 2001). In recent years, domestic institutions set up many information ethics courses. Although the topic of 'information ethics' is not numerous, moral education is an imperative issue in Taiwan (Wu, 2007).

When it comes to improving the right of privacy, property, accuracy, and access of information, the information security cannot be ignored. Liu (2004) argued that information security can protect knowledge assets, maintain the competitiveness for s, and avoid personal privacy from being usurped, modified, or known for public. Therefore, in order to put information ethics into practice, not only establishing the ethical standard but also placing importance on information security in corporations. It can prevent substantial loss caused by errors of information system, improper use, and negligence of information management.

CASE INTERVIEW

Basic Information of Cases

In this study, there are five different types of corporations in case interviews to understand the value and progress on information ethics issues of each company. This is a reference design for the subsequence of corporate information ethics indicator.

Table 1: Basic Information of Cases.

Industry	Number of Employees	Main Business
A. Electronics	**10,000**	**Manufacture of Communication Devices**
B. Bank	**6,000**	**Financial Affairs**
C. Technology	**2,000**	**Antivirus Software**
D. Hyper-media	**555**	**Broadband Internet Service**
E. Stock Company	**3,000**	**Stock Exchange Agency**

Results of Case Interview

There are several indicator assessments to identify the extent of the value and progress of corporate information ethics, as follow:

1. Setting up the regulations will help employees to understand the information ethical policy.

Corporations all consider that setting up the regulations for information ethics is a measuring perspective for assessing the extent of the value and progress of information ethics. When it comes to ordering the information ethics on employees, setting up regulations is the most important. It makes employees understanding the company policy, and provides criteria for facing ethical dilemma.

2. IT education develops information ethics within companies.

IT education is an important factor for developing correct concept of information ethics. However, in order to put relative courses or trainings into practice, plenty of cost is required for corporations. Therefore referring to carrying out the IT education, the larger scale a corporation has, the more it values IT education.

3. Corporations start to limit the use of instant messenger software.

According to the iThome survey of using instant messengers from top 300 corporations in Taiwan, most of the corporations allow the use of IM on certain conditions (iThome, 2006). From the case interviews of this study, it is found that most of the uses of IM are totally forbidden or opened on the conditions judging from the information security. This result was the same as iThome survey.

4. Applying the international standards to the concrete practices of information ethic issues in corporations.

Following the international standards is not equal to the quality of information ethics, but these international standards in the aspects of information data, software/hardware equipments, organization process, and human resource arrangement implicitly contained information ethics PAPA issues mostly. While a corporation adopts some standard of bill of an international organization, it shows great consideration and awareness on information ethics. Therefore, applying the international standards will promote the concrete practices of information ethic issues in corporations.

RESEARCH DESIGN

The aim of this study is to construct and develop an evaluation system of corporate information ethics indicators on the base of motives and expectations, literature review, and outcome of case interviews.

Framework of information ethics indicators for corporations

The outcome is shown as a hierarchical framework in Fig. 1.

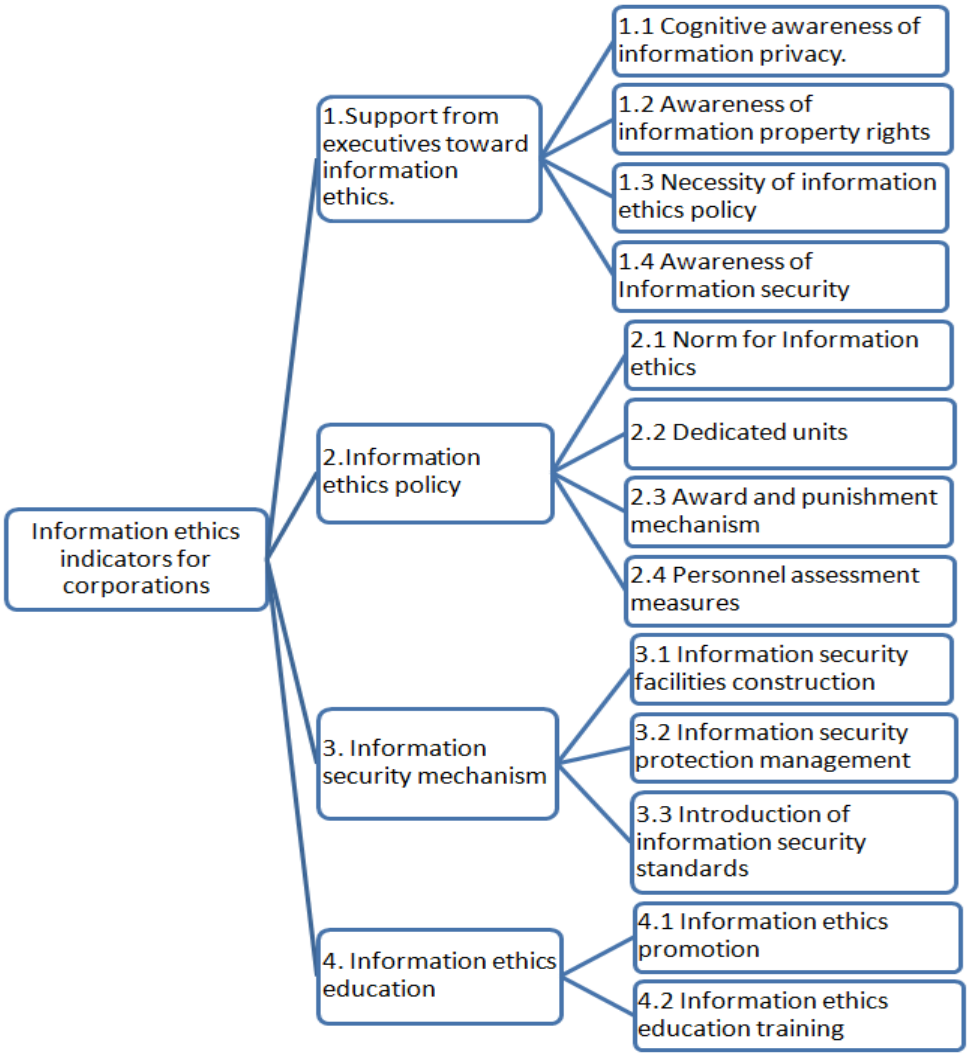

Figure 1: The framework of information ethics indicators for corporations.

Indicators Illustration

The whole framework consists of four main aspects: support from executives toward information ethics, information ethics policy, information security mechanism and information ethics education. The aspect of "support from executives toward information ethics" contains 4 main ideas: cognitive awareness of information privacy, awareness of information property rights, necessity of information ethics policy and awareness of information security. Detailed indicators are listed in Table 2.

Table2: The content of indicators about executive support toward information ethics.

No.	Content
1.	Executive support toward information ethics.
1.1	Cognitive awareness of information privacy.
1.1.1	The collection and usage of personal data is only limited in the relevant range.
1.1.2	The collection and possessing of personal data is obliged to inform the persons concerned.
1.1.3	In prevention to the occurrence of damage, the design of personal information privacy protection system is to avoid information abuse.
1.1.4	Business use of personal data in accordance to the purpose has the obligation to maintain informaiton accuracy and completeness.
1.1.5	The personal data within corporations should be well-protected. （Ex. unauthorized interception, usage, modification or disclosure of personal information unpermitted.）
1.2	Awareness of information property rights
1.2.1	The scope of information property rights includes copyright, patent, trademark right and trade secrets and so on.
1.2.2	Information usage may relate to the issues of privacy, trade secrets and copyright.
1.2.3	Any respect of information reproduction will relate to property issues(Ex. music, software programs）
1.2.4	To understand that personnel within the corporation using pirated software will cause corporations to cast the stigma of violations of property rights, or to bear the loss of money and goodwill.
1.3	Necessity of information ethics policy
1.3.1	Can information ethics policy effectively reduce the occurrence of information abuse?
1.3.2	Can information ethics policy do as guidelines when employees facing the ethical dilemma?
1.3.3	Can information ethics policy enhance corporate ethical issues?
1.3.4	Do positive effects reflect on the corporate image when businesses execute information ethics policy?
1.4	Awareness of Information security
1.4.1	Firms have the obligation to protect information confidentiality.
1.4.2	The accuracy and availability of information must be managed efficiently.
1.4.3	Unauthorized organization staff should not access the resources of the computer and communication service.
1.4.4	Information security system is established to ensure legal access of the information resources and sustain the operation of commercial activities.

There are four main ideas under information ethics policy aspect: information ethics, corresponding sectors, award and punishment mechanisms, and personnel assessment measures. Detailed indicators are shown in table 3.

Table3: The content of information ethics policy indicators.

No.	Content
2.	**Information ethics policy**
2.1	**Norms for Information ethics**
2.1.1	**Whether the organization maps out norms regarding information ethics or not?**
2.1.2	**Whether the content is compatible with the existing laws or not?**
2.1.3	**Whether ethical norms formulated by the organization include information abuse or not? (Ex. Computer/Internet use in non-work-related affairs)**
2.1.4	**Whether the ethical norms are clearly understandable or not?**
2.1.5	**Whether the ethical norms have real examples as references or not?**
2.1.6	**Whether the ethical norms are revised in response to business needs or not?**
2.1.7	**Whether members in the organization are informed or not?**
2.1.8	**Whether ethical norms vary among organizational hierarchies or not (Ex. the higher level is bound to stricter constraints.)**
2.1.9	**Whether reward and punishment approaches are drawn up in ethical norms or not?**
2.2	**Dedicated units**
2.2.1	**Are there any concerning sectors responsible for the implementation of information ethics?**
2.2.2	**Whether the information ethics sector implement according to the ethical norms set by the organization or not?**
2.2.3	**Whether the information ethics sector keeps monitoring and managing the implementation of ethical norms or not?**
2.2.4	**Whether the information ethics sector builds up ways of communication on the implementation of ethical norms or not (Ex. online message boards, e-mail or virtual communities, etc.)**
2.3	**Award and punishment mechanism**
2.3.1	**Whether the award and punishment mechanism is in accordance to the ethical norms set by the organization or not?**
2.3.2	**Whether the rule in the behavior of employee is clear or not?**
2.3.3	**Whether the rule in the behavior of employee is fair or not?**
2.3.4	**Whether the rule in the behavior of employee is appropriate or not?**
2.3.5	**Whether the rule in the behavior of employee is promptly or not?**
2.4	**Personnel assessment measures**
2.4.1	**Whether the promotion institution within the organization is associated with the employee ethical behavior or not?**
2.4.2	**Whether employee performance is linked to the behavior of his subordinate?**

There are three main points in the aspect of information security mechanism: information security facilities construction, information security protection management, and introduction of information security standards. Details are shown in table 4.

Table 4: Content of information security mechanism indicators.

No.	Content
3.	**Information security mechanism**
3.1	**Information security facilities construction**
3.1.1	**Is there any software tool for checking or diagnosing information security or not?**
3.1.2	**Whether systems of the organization use legal antivirus software and update virus codes all the time or not?**
3.1.3	**Whether there are any concrete security systems in the organization or not?**
3.1.4	**Are there Internet guarding systems or not? (Ex. Intrusion detection system /firewall.)**
3.2	**Information security protection management**
3.2.1	**Whether information access control policies conform to regulations in concerned laws and contracts for information protection or not?**
3.2.2	**Whether the organization maps out norms of management regarding storage devices or not? (Ex. Hard drive /magnetic tape / flash memory.)**
3.2.3	**Whether the organization has daily processing procedures sustaining information security or not? (Ex. Regular data backup/scanning for virus /operating environment monitoring.）**
3.2.4	**Is there an explicit regulation regarding e-mail delivery?**
3.2.5	**Is there an explicit regulation regarding staff's Internet usage? (Ex. Non-work-related upload /download.)**
3.2.6	**Is there any managing regulation especially regarding IM? (Ex. Authorized sectors /non-work-related chatting.)**
3.2.7	**Whether the organization sets up any personnel or sector solely responsible for information security or not?**
3.2.8	**Is there an authorization regulation for interior information assets? (Ex. Management of accounts / passwords.)**
3.2.9	**Is there any regulation regarding information access and authorization control to a**
3.3	**Introduction of information security standards**
3.3.1	**Whether the organization introduces any international standards regarding information security or not? (Ex. BS7799 or COBIT.)**
3.3.2	**Whether the organization introduces any international standards improving information system quality or not? (Ex. ITIL, ISO, etc.)**

Information ethics education aspect, which checks if a corporation implements information ethics education with concrete training and promoting measures, is divided into two parts: information ethics promotion and information ethics education training. Details are shown in table 5.

Table 5: Contents of information ethics education indicator.

No.	Content
4.	**Information ethics education**
4.1	**Information ethics promotion**
4.1.1	**Whether the organization makes regular promotions regarding regulations of information ethics or not?**
4.1.2	**Whether the orientation includes any illustrations regarding regulations of information ethics or not?**
4.1.3	**Whether the organization encourages staff take information ethics courses or not?**
4.1.4	**Are regulations regarding information ethics available for the staffs to browse or not?**
4.2	**Information ethics education training**
4.2.1	**Whether supervisors think highly of issues regarding information ethics education or not?**
4.2.2	**Whether the organization provides any courses regarding information ethics training or not?**
4.2.3	**Whether the organization encourages employees to join training courses or conferences regarding information ethics or not?**
4.2.4	**Whether the organization invites external people to give speeches on information ethics or not?**
4.2.5	**Whether the organization evaluates results of information ethics training or not? (Ex. ethics tests.)**

Consultation Samples and Methods

To effectively integrate academic and industrial opinions and to establish a proper structure of indicators, we consult some experts who possess actual experiences about information ethics in academies and corporations. This study conducted 13 interviewees, 8 of which are senior scholars having specialized in the field of information ethics, and 5 are corporate experts who have ever implemented information ethics activities.

In this research Delphi Method is used to receive collective opinion with repeated questionnaire surveys. According to Murry & Hammons（1995）, after consulting related literature and adjusting itself, a survey was developed a structural questionnaire to reduce the time of examining the questions. Therefore, in the first round a half-structural questionnaire is adopted, in which each answerer not only selects specific options but also gives additional responses (feedbacks, extra information, etc.)

Instruments for Statistics Analysis

Firstly the information ethics indicators are set up according to literature reviews and cases interviews, and then used Delphi questionnaires to consult with the experts in academies and corporations to reassure the completeness of the indicators in this study.

The first round questionnaires are evaluated by two parts. The first part concerns the appropriateness of the main constucts, and the second focuses on specific indicators of each

consturct. Likert six-point scale was adopted to judge the degree of appropriateness; larger numbers shows greater appropriateness.

Methods for Statistics Analysis

Standard deviation and average numbers are employed to comprehend and analyze the experts' opinions about the appropriateness of the indicators. When the average score of an indicator is higher than 4.0, this indicator is qualified; if the standard deviation of the score is less than 1, it means that the indicator is supported by the experts for a certain degree; ones regarded as inappropriate by 20% of the experts is delete.

RESULTS AND ANALYSIS

Backgrounds of experts

There were 13 experts invited to be consultants in this research. They received the Delphi questionnaires, evaluated the fitness of the information ethics indicators, and gave feedbacks. Among the experts in this study, 62% are from schools, and the rest are from business. Only one of them is engaged in information ethics studies or activities for less than 1 year, 4 for 1~3years, 3 for 3~5years, 5 for more than 5years.

Results of Modification

According to experts' suggestions, results of modification are listed below by the order of the four main aspects.

Support from executives toward information ethics.

23% of the experts consider that support toward information ethics is not equal to the concept of cognition. So, one of the items were changed to "support and cognition from executives toward information ethics." Three new ideas and three new indicators were added (seen in table 6). Former idea 1.4 "awareness of information security" was deleted and its indicator was reconstructed to other dimensions. After modification, there were 6 dimensions and 20 indicators in this aspect.

Table 6: New items in aspect 1.

No.	Content
1.3	**Awareness of information accuracy**
1.4	**Awareness of information accessibility**
1.6	**Degree of support toward information ethics**
1.6.2	**To know the importance of information property right to individuals and corporations and propose its well-arrange protection.**
1.6.3	**To know the necessity of information ethics policy and urge an implementation of it.**
1.6.4	**To work on establishing an information security management system, ensure legal access to information sources and sustain normal operation of business.**

Information ethics policy

In this aspect, indicator 2.1.9 and 2.4.2 were deleted due to 20% of experts' suggestion and a lower average score than 4, and 4 new indicators were added (seen in table 7). In the end, there were 4 dimensions and 22 indicators in information ethics policy aspect.

Table 7: New items in aspect 2.

No.	Content
2.2.5	**Whether information ethics sector provides consultant services about information ethics issues and legal problems or not?**
2.2.6	**Whether information ethics sector monitors and evaluates personnel and sectors that probably involved in information ethics problems or not?**
2.4.2	**Is there a positive correlation between information ethics on staff behavior and merit system in the organization?**
2.4.3	**Is there a positive correlation between staff information ethics behavior and bonus system in the organization?**

Information security mechanism

More than 23% of the experts thought that category of information ethics cannot fully cover information security, so after consulting experts and adviser of this research, the title of this aspect was rephrased as "information ethics control mechanism." Two new constructs, "information ethics techniques" and "information ethics management," are added, and the former constructs were deleted. Indicators originally under old three constructs were moved to under new ones, and a new indicator was suggested to be included. There were 2 dimensions and 16 indicators in the modified aspect.

Table 8: New items in aspect 3.

No.	Content
3.1.5	**Whether the organization set up an off-premise backup system to ensure normal operation of information access or not?**

Information ethics education

Indicator 4.1.3 was deleted according to 20% of experts' suggestion; indicator 4.2.2 and 4.2.4 are too similar to be combined; 4.1.2 was moved to 4.2 "Information ethics education training" because it was much more related to that construct. After modification, this aspect contains two dimensions and 10 indicators.

Table 9: New items in aspect 4.

No.	Content
4.2.6	**Annual number of personnel who attend information ethics education training in the organization.**
4.2.7	**Annual hours taken for information ethics education training in the organization.**
4.2.8	**Whether the organization give fortified information ethics education to personnel and sectors that probably involved in information ethics problems or not?**

CONCLUSIONS

The original framework of information ethics indicators has four aspects and 13 constructs and 61 indicators under. After the modification according to experts' advice, it contains 14 constructs and 68 indicators.

The result of this study can provide organizations with a reliable and valid tool for evaluating corporate practice on the information ethics. But practical research will alter with time and environment. The following researchers can refer to this framework and adjust the contents, to construct an more adaptable and profitable device.

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TECHNOLOGY AND MANAGEMENT INNOVATION IN PUBLIC-PRIVATE PARTNERSHIPS: A NEW WIN-WIN-WIN MODEL FOR THE HONG KONG POLICE FORCE

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ABSTRACT

The advantages of using a Public-Private Partnership (PPP) have been widely documented in contemporary literature. Traditionally, Public-Private Partnership (PPP) models are classified into Design-Build-Operate (DBO), Build-Operate-Transfer (BOT), Build-Own-Operate-Transfer (BOOT) and Build-Own-Operate (BOO). This paper proposes a new PPP Business Model, namely, PPP-WWW, as a novel approach to address the operational challenge to emergency services that arise from inadequate indoor radio coverage in the Hong Kong Special Administrative Region (HKSAR). On average the HK Police Force receives ten thousand 999/911 emergency calls daily. The HKPF performance pledge strives to respond to all genuine emergency calls within 9 minutes in the urban area and 15 minutes in the rural territory. A review of the challenges associated with the highly profiled HK Police Force project, a Third Generation Command and Control Communications System (CC3) in support of frontline beat patrol police officers, is examined. The new PPP-WWW pilot scheme was implemented successfully in 2009-2010 with the following key achievements: (1) A creative, innovative and sensible solution was evident with the new Public-private Partnerships (PPP) business model; (2) Timely services delivered, within budget and meeting all user requirements. The implementation period was shortened from 3 to 6 months with projected cost saving of around 40% in comparison with the other engineering solutions achieving similar results; (3) CC3 indoor radio coverage at pilot shopping had been enhanced covering over 640,000 sq. fleet of floor space; (4) Rental and electricity charges waivers were granted by the Shopping Mall and (5) Excellent feedback was received from the end-users.

Keywords: Public-private Partnership (PPP), Innovation, Indoor Radio Coverage, Terrestrial Trunked Radio (TETRA), Third Generation Command and Control Communications (CC3)

Abbreviations

3G	3rd-generation Mobile Communications
4G	Long Term Evolution, LTE
BDA	Bi-directional Amplifiers
CC3	Third Generation Command and Control Communications System
DAS	Distributed Antenna System
dB	Decibel (dB)
DMO	Direct Mode Operation
GDP	Gross Domestic Product
GSM	Global System for Mobile Communications
HKPF	The Hong Kong Police Force
IRN	Integrated Radio Network
MTRCL	Mass Transit Railway Corporation Limited
OFTA	Office of the Telecommunications Authority
PCS	Personal Communications Services
PDAs	Personal Digital Assistants
PPP	Public Private Partnership
RES	Radio Enhancement System
TETRA	Terrestrial Trunked Radio

INTRODUCTION

"The United States suffered a tremendous loss of lives in four separate and almost simultaneous attacks on September 11, 2001. One of the key lessons learned from the terrorist attacks of 9/11 is that adequate and reliable in-building public radio coverage is vital for the first responders to saving lives." (Private-public Sector Partnerships for Emergency Preparedness, 2003)

Figure 1: 911 Photos (Source: http://x9.org.tw/blog/img/thumb-911zn2.jpg).

The Hong Kong Police Force (HKPF) rolled out the Third Generation Command and Control

Communications System (CC3) in March 2006. CC3 was designed and developed to meet the challenges of a fast changing environment and advancing technology, as well as the ever-increasing expectation for better police services and faster emergency responses. It was primarily designed for outdoor radio communications during the initial rollout.

Reliable and efficient radio communications are essential for day-to-day policing duties. Seamless radio coverage, in particular indoor coverage, has always been a common challenge (Rappaport, 1996) to all mobile radio systems and police radio waves are of no exception, especially for beat police officers patrolling inside buildings such as shopping malls, basement floors, and carparks. Modern metropolis such as Hong Kong, London, and New York are commonly known as concrete jungles packed with skyscrapers.

To cope with the intensive metropolitan development in Hong Kong, developers are building more indoor shopping malls, thereby creating even bigger operational challenges for frontline patrolling officers in carrying out their police duties at these indoor areas. Hence, indoor radio communications are becoming an essential requirement to support daily police duties. Obviously, it is not practical to build a new comprehensive radio infrastructure inside all shopping malls in the constraints of time, cost and technicalities.

What are the problems?

In recent years the growth of public and private mobile radio communications has meant that the provision of seamless radio coverage has evolved from a desirable to an essential requirement. Especially, emergency services need clear and reliable radio communications for efficient incident management and personal safety. Imagine the case that police officers enter a building in response to a jewellery shop robbery incident, where some ladies and children are taken hostage. As the officers approach the crime site, they realize that the situation is beyond their capabilities. They definitely need additional assistance and equipments to handle the emergency. Next, the officers use the police radios to call their dispatch centre, requesting additional assistance and back up support. They wait for the dispatch centre to respond, but no reply is received. Then, they try to communicate through radio to other police teams in the street outside the building. Again, there is no reply. They try both methods repeatedly but still gain no reply. These officers know they cannot handle the incident without assistance, so they decide to make their way back outdoors, where there is a high chance of getting connected to the dispatch centre or other police teams who are nearby.

As a result, precious time is lost while trying to find a location where police radio

communications are possible. In many cases, officers need to travel completely outside the building before they can make use of their police radios to communicate. In a worst case, officers inside the building are trapped, injured or killed, and they cannot make contact with anyone. Indoor radio coverage is therefore essential for public-safety networks in tunnels, railway and subway stations, convention centres, hospitals, airports, and other special locations.

PROBLEM ANALYSIS

The Law of Physics

The poor indoor radio coverage is caused by both building losses and by interference from intentional or unintentional transmitters. The law of physics can explain the building losses. The signal waves from the radio normally start at the transmitter tower located on a hilltop or building-top. The waves are reduced as they travel to and from the radio. The amount of loss varies under different materials, and is diminished even over the air. This means that anything attenuates or reduces the radio waves. On the other hand, each radio has a minimum signal level that it must receive in order to work. The signal waves begin out high and are reduced along its path to the radio. Buildings and their construction materials, such as concrete, cinderblock, steel, brick and tinted glass, all reduce the radio waves. So buildings are not friends of the first responders. These construction materials, used in most large structures, absorb radio waves. The strong outside radio waves quickly become non-existence on the inside of the building. Path loss is a major component in the analysis and design of the link budget and signal loss of a radio system.

Problem Owners and Existing Solutions

Many public safety agencies believe that it is fair and reasonable to make the building developer or owner responsible for assuring a viable public safety radio signal, throughout his or her property. This is particularly true when the building itself greatly attenuates the public safety radio waves, plus activities inside the building warrant a genuine need of public safety response to the site. Some municipalities in the US and Europe have written building or fire codes to address the problem. The building developer or owner is required to comply with the code before a certificate of occupancy is issued. However, results are often undesirable because the code is usually not written in a language that is measurable or enforceable, or the problem is seemingly insurmountable because of legacy. The alternative is, therefore, to place the burden of adequate radio coverage on the community as a whole, or to settle for situations where public safety communications are not at all reliable.

Worldwide public safety agencies, including fire jurisdictions and police authorities, have adopted standards[1] for in-building public safety radio enhancement system (RES). These standards are developed to ensure adequate indoor radio coverage for fire fighters and police officers for emergency response. RES is better known in the industry as Distributed Antenna System (DAS), which is the typical solution to address the indoor radio coverage problem. DAS, as shown in Figure 2 that uses the pilot scheme in Telford Plaza as an example, is a network of components that distributes radio signals throughout the building from a central point. The system takes radio waves, amplifies and distributes them, by an off-air bi-directional amplifier (BDA) connected to an outside antenna which points to a donor site and a cabling structure[2]. Then, the BDA transmits the waves through remote antennas to provide adequate radio coverage. Apparently, DAS seems to give a solution to improve the in-building radio coverage for anyone who uses a cell phone, a police radio, or a wireless laptop. Using such traditional design of repeater systems, with distributed antennas or radiating coaxial feeders can obtain seamless internal radio coverage. A DAS solution does bear high installation costs and has a lengthy implementation time.

Another common solution is that Police deploy in-vehicle transportable repeaters to extend the range of police communications. Though the ad hoc repeater solution is not perfect, it has obvious advantages of easy and quick set up. And it can support limited internal coverage during emergency response.

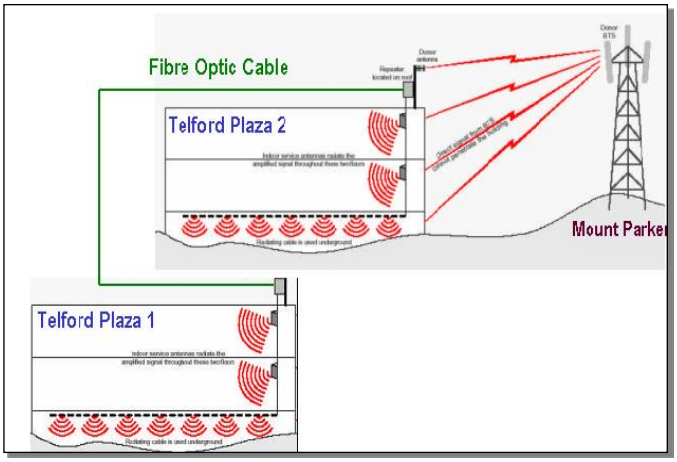

Figure 2: Distributed Antenna System at Telford Shopping Plaza.

[1] Section 510 of the International Fire Code (IFC), International Building Code, National Fire Protection Association (NFPA) Fire Code, and Recommendation 22 of the National Institute of Standards and Technology (NIST) are common industry standards.

[2] The cabling structure is normally made of coaxial cable or fibre optic (radio-over-fibre) depending on the length.

Concerns and Issues

The world is urbanizing at a rapid rate. In just a half century the world urban rate of population increase grew from about 30% to about 50% (Trzyna, 2007). There are growing police concerns and security problems associated with urbanization. Modern metropolis like New York, London, Tokyo, Dubai, Shanghai and Hong Kong are commonly known as digital cities. And ubiquitous wireless broadband connectivity is the key element for a digital city. These cities are concrete jungles packed with skyscrapers and underground cities. They are very dynamic and their infrastructure development will never stop. To cope with the extensive metropolitan development Hong Kong developers are building more indoor shopping malls, sport facilities, convention centers, hospitals, and warehouses. This trend poses even bigger operational and economical challenges to public safety in-building radio communications and emergency response.

It is seemingly mission impossible to refurbish all legacy buildings or to build a totally new comprehensive radio infrastructure for public safety inside all buildings, taking the constraints of time, cost and technicalities into consideration. On the other hand, real estate and public safety communities are challenged with providing full comprehensive radio coverage in parking garages, elevators, and open areas for both commercial devices like cell phones, smart phones, personal digital assistants (PDAs) and public safety radios. Building developers and owners now rate the ability to coordinate with local emergency responders as the most important public safety feature. Developers have a stronger motivation to meet building and fire codes involving safety. And they need better solutions that clear in-building radio coverage is made available for emergency personnel.

Likewise, first emergency responders are also nervous about switching from analogue to digital radio systems, where there is insufficient indoor coverage. This trend has accelerated during these years, with many discussions amongst all parties involved, and reflected as well as the conference program as a topic of increasing importance.

FINDINGS

Public Sector Reform

The Government is committed to providing the best services it can for the community. Its goal of enhancing public sector productivity and keeping down the public sector's share of the Gross Domestic Product (GDP) means that the police sector must examine new ways of providing services other than increasing the size of civil service. Private Sector Involvement

has been woven into the Government's reform measures, mainly in the form of outsourcing and public private partnership (PPP) (Grimsey and Lewis, 2004). In Hong Kong, PPP continues to be encouraged within the public sector as a means to improve coverage, effectiveness, efficiency and quality in the delivery of public services. With the few exceptions of Australia and Los Angeles, PPP has yet to be applied in emergency services worldwide. In fact, the Los Angeles County Police model has proved to provide a level of flexibility not achieved in a police officer–only model (but joined by private security resources). The authors were inspired to introduce a somewhat different application of the PPP model in a business case of providing reliable indoor police radio communications in a digital city like Hong Kong. Such model is depicted in Figure 3. The model allows the HKPF to use the spare communication bandwidth capacity of various mobile operators on-demand and in a just-in-time manner.

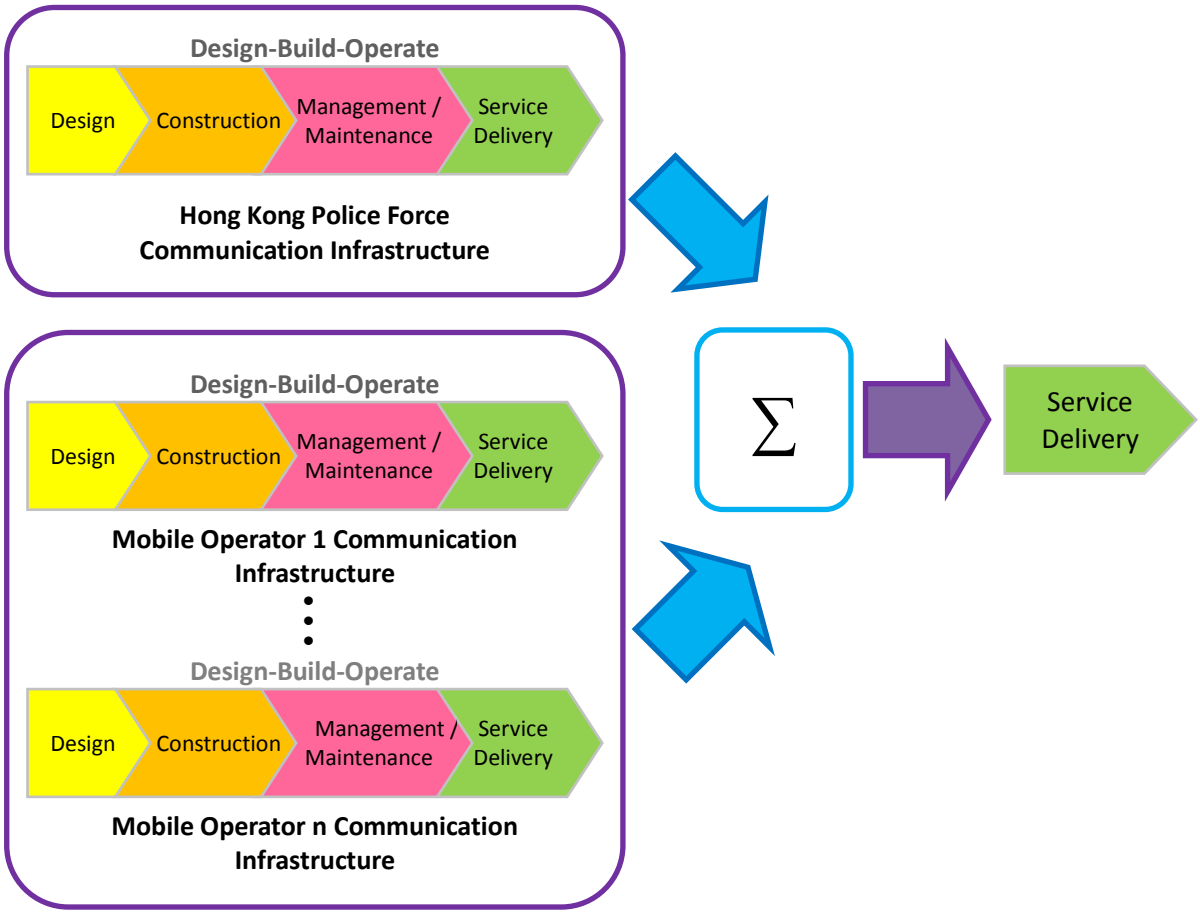

Figure 3: A Public-Private- Partnership-Win-Win-Win Business Model.

The Hong Kong public sector reform was originally conceived to provide focus for sustaining the integrity, efficiency and effectiveness of the public service during the transition in 1997. Through the development of the political accountability system it is now time to look forward to the tests that public service, including the police, will face in the next decade and

consider how the public service, as an institution, will rise to the 21st century challenges.

Change is Constant

Extensive criticism is frequently voiced against governments and bureaucracies worldwide, suggesting that the perceived rigid-red-tape nature, inefficiency, lack of flexibility, and negative attitudes towards change, will restrict social progress and economic growth in modern states. The Hong Kong civil service itself faces a huge social change, as the great "baby boomer" generation who built the new towns and other infrastructure projects of the last three decades retire and make way for a fresh influx of talent and ideas. The speed of change is increasing. This presents an opportunity to re-engineer and redeploy the public service to meet the needs of an evolving political system and an ageing, more socially diverse population, characterised by more rapidly changing ideas and opinions. Change is constant in today's world. Public service sustainability is therefore fundamental to the public security that individuals, families and business can enjoy in Hong Kong. Sustaining that framework with integrity, acumen and innovation is the responsibility of every public manager. And innovation is particularly relevant to increase the value delivered to stakeholders in a new environment.

Managing Changes by Innovation

Innovation is absolutely important in a public sector. Constant change requires constant innovation. In brief, there are three types of innovation: Technology Based Innovation, Design Based Innovation, and Business Model Based Innovation. In today's changing world it is imperative that public sector effectiveness and efficiency is constantly increased to deliver on constantly increasing value expectations made by the key stakeholders. In order to deliver on these expectations, it is essential to integrate the three types of innovation.

The Hong Kong Police Force has successfully rolled out the Third Generation Command and Control Communications System (CC3) in support of frontline beat patrol officers since 2006. Reliable and efficient radio communications are essential for their day-to-day policing duties. Seamless indoor radio coverage has always been a common challenge to all mobile radio systems and police radio waves are no exception, especially when beat officers are patrolling inside buildings such as shopping malls, basement floors, and carparks. The project work has a clear focus, about meeting the challenges of in-building police radio black-spots, by developing and deploying a novel and affordable technical design with an innovative business model, for the public safety sector to share the infrastructure facilities (in-building transmission and antennae systems) of the commercial mobile operators, with a view to

achieving win-win-win outcomes for stakeholders – police, commercial mobile operators, and members of the public.

PILOT SCHEME

Background

In 2008, police regions were invited to critically examine the locations where indoor coverage was absolutely essential according to the criteria laid down by the CC3 Operation Implementation Team. The criteria include: -

- Number of Incidents;
- Crime Reports;
- Pedestrian Average;
- Pedestrian Peak;
- High Risk Premises; and
- Public Events.

Based on some detailed analysis of the user requirement and factual statistical data submitted by police regions, 59 specific indoor locations were selected and endorsed by the HK Police Force Management for enhancement with CC3 indoor radio coverage.

To prove the PPP concept, the Telford Shopping Plaza was selected as a pilot site for the CC3 Indoor Coverage Enhancement Project. As the largest regional shopping and entertainment complex in East Kowloon, the Telford Plaza catchment area, as illustrated in Figure 4, will be both far and wide. In addition to the 560,000 East Kowloon residents and the 20,000 residents of Telford Gardens, the close proximity of the Kowloon Bay MTR station provides a steady flow of commuters averaging 150,000 per day.

Figure 4: Telford Shopping Plaza.

This service aligned with the HKPF's strategic direction for supporting frontline units. Such professional mobile radio services will empower frontline units with highly responsive and resilient communications capabilities to meet increasing safety and security needs, in particular patrol sub-units and criminal investigation teams. The frontline officers can respond to the public and solicit assistance in an effective and rapid manner.

Service Design

Efficient, User-friendly and Effective Service

Traditionally the frontline officers had to set-up a gateway repeater in proximity with fairly limited radio coverage to relay the outdoor CC3 signals into the indoor areas or by using the Direct Mode Operation (DMO) of CC3 radios for line-of-sight communications. In response to the operational needs from the frontline officers, this service design provides a quick-win deployment solution to the frontline officers. Officers can now rely on the enhanced radio coverage inside the Telford Plaza with seamless transition experience and without any communication interruptions or any manual interventions.

Innovation

Following the detailed survey, there are 76.3% (45) of locations with very good public mobile operator coverage at these 59 selected indoor locations. As such, HKPF can enjoy the radio coverage at such locations by riding CC3 radio on the public mobile operators' infrastructure. Currently, there are five public mobile operators in Hong Kong that deliver seamless mobile phone services inside the shopping malls with general radio penetration of over 95% at public areas. Three field trials were conducted with the mobile operators at Cheong Hing

Square, Yuen Long Neway Karaoke and Fu Chong Shopping Centre with encouraging results.

Taking the advantage of the technology, this enhancement project employed the wideband radio equipment (380MHz to 2100MHz) for CC3 radio signal riding on the current public mobile operators' infrastructure. The solution (riding on the public mobile operators' antenna and transmission infrastructure) is proven and the synergy effect has been evident during these field trials. Hence, the creative and innovative ideas were adopted for the delivery of the service.

Also, a new business model (Public-Private Partnership - PPP) between public and private sectors regarding the provision of public services over a private infrastructure is established. Purportedly, this is an effective means of bringing together social priorities with the managerial skills of the private sector, relieving the government from the burden of large capital expenditure, and transferring the risk of cost overruns. Rather than completely transferring public assets to the private sector, as with privatization, government and business work together to provide exceptional services.

Cost effectiveness

The aforesaid solution has been successfully delivered at Telford Plaza since August 2009. The project was commissioned by one of the public mobile operators in collaboration with Mass Transit Railway Corporation Limited (MTRCL) maintenance contractors, through competitive tendering, at an affordable cost. The cost saving is around 40% in comparison with the other engineering solutions but with an effective use of the existing resources inside the shopping mall. This initiative introduced minimal investment with maximum benefits to HKPF.

Service Implementation

Staff Communication

The Communications Branch of the HKPF played a leading role in providing close liaison with frontline officers to formulate the service strategy and implementation plan for the delivery of services. The disturbance to the end users was minimal.

Difficulties and Challenges

In the planning stage, it was anticipated that the following difficulties would happen during the implementation stage:

- Installation works at the shopping mall's public areas and inside the shop might affect the customer flows and be a high concern of the Management Office.
- The location of the outdoor antenna near the residential areas may cause inconvenience to the residents of Telford Garden.
- The selection criteria of the wideband radio component should consider the system scalability to Mobile 4G (Long Term Evolution, LTE) delivery in future.
- The appearance of the indoor antenna should match the indoor environment and not affect the corporate image of the Shopping Mall.

These inherent difficulties were factored into the design consideration during the detailed design stage. These challenges had been tackled and handled properly by a flexible and proactive approach:

- Night works were carried out at public areas after the closing of the shopping mall. In these locations, that did not allow for access for installation works, the antenna were relocated and diverted with detailed engineering prediction.
- Close liaison with the shopping mall management office to successfully install an outdoor antenna at the podium level of the commercial building and far away from residential areas was achieved.
- Wide band radio components were selected and will also fitted for the wideband Mobile delivery in future.
- The appearance and colour scheme of the antenna was approved by the shopping mall prior the installation.

End-users Early Buy-in

Upon the completion of works, the frontline officers were invited to take part in the User Acceptance Test at Telford Plaza. This ensured the services delivered would meet the user operational requirement in action.

Continuous Improvement

A project review was carried out by the senior management with post-implementation customer feedback. The lessons learned in the pilot scheme would be adopted for the full deployment works at remaining 58 locations. Under the new indoor premises, pre-provision of Radio Injection Ports for HKPF is to be considered with the policy support from Office of the Telecommunications Authority (OFTA). That will be beneficial and entail a minimal retrofit required for extending police radio coverage into the new indoor

premises.

RESULTS

On average the HKPF receives ten thousand 999 emergency calls daily. The performance pledge is to strive to respond to all genuine emergency calls within 9 minutes in the urban area and 15 minutes in the rural territory. As a continuous improvement initiative, the pilot scheme at Telford Plaza was implemented successfully in Aug 2009 with the following key achievements:

- A creative, innovative and sensible solution was evident with the new business model of Public-private Partnerships (PPP) (Grimsey and Lewis, 2004).
- Services delivered timely, within budget and meeting all user requirements. The implementation period was shortened from 3 to 6 months with projected cost saving of around 40% in comparison with the other engineering solutions achieving the same results.
- CC3 indoor radio coverage at Telford Plaza was enhanced, covering over 640,000 sq. fleet of floor space.
- Rental and electricity charges waivers were granted by the Shopping Mall.
- Excellent feedback was received from the end-users.

CONCLUSION

The operational challenge of extending radio communication support to frontline officers in the discharge of their duties at the indoor shopping malls has been met by this novel PPP approach. The operational efficiency and personal safety of frontline officers was achieved and the public safety to the community was enhanced.

Moreover, there are three perceived benefits of the “PPP Model” to both Government and Community. First, private sector resources, expertise and creativity, were exploited. Second, the commercial potential of government-held project (value-added commercial services are normally not government’s core-business), were maximized. Third, costs and risks have been managed in a proper manner and under strict control.

CC3 is a mission critical system for emergency response. Its productivity cannot be quantified but it enables the police to respond faster to emergencies. The time saved greatly enhances the chance of saving life in life and death situations. As a result of the innovation Hong Kong remains one of the safest and most stable cities in the world.

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THE INVERTED U-SHAPED RELATIONSHIP BETWEEN BUSINESS UNITS' SLACK AND PERFORMANCE: THE CASE OF INDONESIA[1]

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ABSTRACT

This study reconciles the positive and negative views of behavioral theory of the firm and economists regarding slack. This study tested the non-linear effect of business units' slack to its performance outcome on 135 manufacturing business units in Indonesia. Using non-monotonic structural equations modeling, the study showed that corporate diversification positively affects the budgetary slack while it provides little evidence for the significant effect on financial slack. The study also indicated that both the financial and budgetary slack increased the financial and non-financial performance at some "peak" levels, and beyond them, they would hurt the business units performance.

Keywords: financial slack, budgetary slack, financial and non financial performance

INTRODUCTION

Slack that is defined as the excess of resources above the necessary minimum to produce a given level of organizational output has been an important and intriguing domain in management accounting literature. Particularly it is because of the opposing theoretical streams among economists and behavioral accountants on the true role of slack that have led confusions among the researchers to justify the conclusive, robust findings. Accounting "behaviorists" for instance, have evoked the use of idle resources that may act as a buffer from environmental pressures (Lin et al. 2008, Patzelt et al. 2008, Geiger & Makri 2006, George 2008, Stede, 2000; 2001a; Cyert & March, 1963), or as a shock absorber (Merchant 1985), and as a buffer to engage in risk taking/innovative behavior (Yang et al. 2009, Herold et al., 2006; Love & Nohria, 2005). These "idle resources" are, therefore, important in providing organizations capabilities to act in ways that are not possible for other organizations poorer in resources (Nohria & Gulati, 1996). George (2005) maintained that the presence of slack can be used as an enactment of strategies. Lawson (2001) urged that attempts to reduce slack may be ill-advised; and in a more provoking position, Martinez and Artz (2006) even argued that "it is not possible for a firm to survive long without the presence of resources above and beyond its immediate needs" (p.12)

On the other hand, economists such as Jensen (1986; 1993) and Jensen and Meckling (1986) argued that slack reduces incentives to innovate and promotes undisciplined investment in R&D activities. They further argued that this slack creation rarely yield economic benefits and reflects the self-serving interest of managers. Bourgeois (1981) and Yasai-Ardekani

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(1986) documented that slack promotes the creation of suboptimal systems, processes, and structures that reduce a firm's aggressive explorations of new responses (e.g. innovation, creativity). In fact, as been noted by Cheng and Kesner (1997), the term slack itself conjures up a host of negative perceptions.

This study is not going to pick either side of this debate, but rather this study aims to provide a way out of this intractable debate by reconciling the views of economists and accountants. Particularly, this study proposes that there is a "curse" and at the same, "bless" for both approaches. In simpler words, current study maintains that there is an inverted U-shaped between slack and performance, in which the relationship is positive and may turn to negative when the extent of slack reaches its optimum peak.

Although the positive and negative impact of slack have been recognized in the literature, few research in management accounting has attempted to test whether slack is good or bad for business units performance. Bourgeois (1981), trying to reconcile economists and behaviorists, postulated a curvilinear relationship between slack and organizational performance in general. Recent studies by Nohria and Gulati (1996), Geiger and Cashen (2002) and Herold et al. (2006) have extended the non-linear argument between slack and R&D intensity. They argued that R&D activities cannot be carried out without any slack available; and on the other hand, too much slack may deteriorate the R&D due to wasted spending and careless innovation projects.

Furthermore, this study believes that lack of interpretable results between slack and its outcome may not be looked on the relationships, *per se*. but the focus of the study must also be directed to the slack conceptualization that we believe, is the source of those intractable, unsolved debate. Slack creation, that can be traced back to the behavioral theory of the firm (see seminal works of Cyert and March, 1963 and Bourgeois, 1980) is a multi-dimensional construct, and not as observed variable that can be traced directly to the budgeting process of a firm. The use of subjective measures *per se* raises some question about the accuracy in measuring budgetary slack. Organizational theorists (e.g. Bourgeouis, 1981; Cyert & March, 1963) proposed objective measures of slack in organization that rarely put into considerations in management accounting research, despite its flourishing use of its conceptualizations. Such objective measures were usually operationalized using financial indicators of slack such as absorbed and unabsorbed slack (Singh, 1986) and available (Ahuja, 2000, Combs & Ketchen, 1999), recoverable (Steensma & Corley, 2000) and potential slack (Simerly & Li, 2000, see also Daniel et al., 2004 for a meta analysis). Therefore, in order to provide a more meaningful result, this study looks at slack from the objective and subjective measures.

Therefore, this study aims to examine the non-linear pattern of multidimensional construct of organizational slack to its performance outcome. As a consequence, this study also contributes to the wide-array of accounting literature in several ways. First, this study is among the first to test the non-linear attributes regarding the relationship between slack and performance, in their higher order terms (multi-dimensional constructs). Second, this study provides a way out of the intractable debate between behaviorists and economists by reconciling those views. In particular, this study insists that there is "curse" in both "too few slack" and "too much slack". For instance, too few slack may inhibit the business units to

flexibly engage in their activities because there is no room to make maneuvers (as there is no idle resource). On the other hand, too much slack reveals inefficiency and pursues the business units to make insufficient, pet projects that may not yield economic benefits to the organizations.

This study is decomposed into several sections. The next part of this study explains in detail the literature review and hypotheses developments, while the methodology of the study is explained in the third part. The fourth and fifth parts of the study elaborate the findings and discussion, while the conclusion, limitations and avenues for further research are discussed in the last section.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Nature of Organizational Slack

The leading view of financial (organizational) slack used in the literature is one based on Cyert and March (1963), in their seminal work entitled *A Behavioral Theory of the Firm*. They are credited and cited most often for their preconceived ideas on organizational slack. Their impressive essence conceptualization of slack was excess of payments over the minimum necessary required to maintain the organization that took an additional idea which is so-called "reserved resources". Thus, it is likely that members of the organization may have a different resource needs and different slack requirement depending upon environmental favorableness. Cyert and March (1963) suggest the need for slack as a buffer by proposing that

> …it seems to be useful in dealing with the adjustment of firms to gross shifts in the external environment…When the environment becomes less favorable, organizational slack represents a cushion. Resource scarcity brings on renewed bargaining and tends to cut heavily into the excess payments introduced during plush times…the cushion provided by organizational slack permits firms to survive in the face of adversity. (pp. 37-38)

A great deal of authors have then defined slack into diverse conceptualizations (kindly compare the works of Nohria & Gulati, 1996; George, 2005; Chattopadyay, 2001; Love & Nohria, 2005; Martinez & Artz, 2006, among others). These various conceptualizations also lead to the conflicting stands regarding the benefits and disadvantages of having slack in an organization (refer to table 1)

Table 1: Positive and negative impacts of organizational slack.

Positive impacts of organizational slack	Negative impacts of organizational slack
1. enhance the fit between strategy and structure (George 2005)	1. reflects organizational inefficiency (Bourgeois, 1981; Jensen and Meckling 1978)
2. influences ability of a firm to adapt to its environment (Bourgeois, 1981; Miller et. 1996)	2. encourages a lack of discipline
3. facilitates innovation (Cyert & March, 1963; Herold et al. 2006, Martinez & Artz 2006; Nohria & Gulati 1995)	3. Diminishes incentives to innovate (Jensen 1986)
4. Encourages increased risk-taking (Martinez & Artz, 2006; Singh 1986)	4. enhancing the non-optimizing behavior (Bourgeois 1981, Jensen & Meckling 1978)
5. Facilitates creative strategic behavior (Bourgeois 1981; McGratch & macMillan, 2000; George 2005)	5. Loosen the management control systems (Davis & Stout 1992)
6. Encourages experimentation (Bourgeois 1981)	6. leads to wasted resources and careless spending (McGrath & MacMillan 2000)
7. Encourages increased risk-taking (Singh 1986)	
8. Supports exploitation of opportunities (Bourgeois 1981)	

Financial Slack

Slack resources can be measured using several financial indicators. Most prior researches differentiate slack into three main typologies; which are available, recoverable, and potential slack resources (Bourgeois, 1981; Bourgeois & Singh, 1983; Sharfman et al, 1988; Singh, 1986). Available slack (that can also be referred as unobserved slack) describes the resources that are available but not yet committed for any particular allocation such as the funding for innovation activities or dividend payments to shareholders (Martinez & Artz, 2006). Recoverable slack (as it is sometimes referred as absorbed slack) represents resources that have been allocated and absorbed by the organization but can be easily recovered through cost-cutting and efficiency. One example of recoverable slack is the overhead costs for executive salary. Nevertheless, as pointed out by Herold et al. (2006) and Hendrick (2006), although recoverable slack is theoretically easy to recover, but in practice the recovery could be difficult and may bring out some strong negative consequences. Potential slack on the other hand is simply conceptualized as the organization's future

capability to earn resources. Usually potential slack is basically operationalized as the extent of equity capital owned by the company.

The presence of slack has been linked to the idle capacity of the firms. As company resources increase, the presence of slack in organization also increases, but in a faster rate (e.g. Cyert & March 1963). In contrary, when the company resources decrease, organizational slack decreases, also at a faster rate. The financial mechanism of slack over time is a function of sales growth, profitability, situational and behavioral factors. Leavins (1995) postulated that the slack in the highly performing firms inherently tend to increase, but firms can find many alternative ways to reduce the costs if they are forced to do so. This relationship was modeled by Wolf (1971) as:

$$\frac{\Delta E}{\Delta R} > 0, \frac{\Delta SGE}{\Delta E} > 0 \text{ , and } \frac{\Delta E}{\Delta R} < \frac{\Delta SGE}{\Delta R}$$

Use of resources in a slack building state

$$\frac{\Delta E}{\Delta R} < 0, \frac{\Delta SGE}{\Delta R} < 0 \text{ , and } \frac{\Delta E}{\Delta R} > \frac{\Delta SGE}{\Delta R}$$

Use of resources in a slack reduction state

ΔE indicates the change on profit on time t and t-1 while ΔR denotes the change on revenue, while ΔSGE denotes the change on selling and general expenses. The models obviously evoke the question why firms have lower change of profit while on the profitable situation, and they still can operate normally and earn above-average profit even in a very fierce situation, as is the case of some organizations in the crisis period.

Budgetary Slack

Earlier work defined budgetary slack as the result of management's consciousness and intentional behavior during the budgetary process as an outcome of rigid budgetary evaluation (Schiff and Lewin 1968). Recently, Douglas et al. (2007) defined budgetary slack as the variances of actual spending and budgeted spending and the difference between the expected and actual performance. Garrison et al. (2006) proposed budgetary slack as the consequence of self-imposed budget which might result in inefficiency and waste. On the other hand, Yuen (2004) conceptualized budgetary slack as the building of excess resources in a budget or understating productive capability and thus will make the budget easier to attain. Douglas and Wier (2000) claimed that budgetary biasing behavior is the difference between planned performance target and real performance capabilities. Leavin et al. (1995) insisted that budgetary slack exist due to the results of management conscious and intentional behavior during the budgetary process.

The non-linear relationship between slack and performance

Organizational slack which is the available resources above immediate, required needs is one possible source of funding for many activities. Therefore, several researchers have linked the needs of slack for innovation-lead performance activities. Nohria and Gulati (1996) insisted that slack may increase the undisciplined investment and thereby deteriorating the innovation activities.

A behavioral theory of the firm would maintain that slack to have some positive impacts on performance in several ways (Cyert & March, 1963; Bourgeois, 1981). First, the presence of slack may loosen the managerial controls rigidity of a particular organization (Cyert & March, 1963), allowing manages to embark on discretionary steps in pursuing new projects (Geiger & Makri, 2006). Second, the slack resources can be consumed during bad times and thus becoming less vulnerable to the uncertainty of experimental projects and thereby increasing the innovative cultures (Nohria & Gulati, 1996). Members of the organization are also less likely to worry about the risk of failure in embarking a particular project because they have resources as a buffer against the failure (Geiger & Makri, 2006).

On the other hand, slack has been argued to have some negative impacts on performance as the managers may utilize the slack resources for less risky activities thereby may decrease the experimentation and innovation activities (Denis et al., 1999; Jensen, 1986). Agency perspective also warned the use of slack not as to foster experimentation and innovation, rather as a resource to maximize their own personal wealth or interests. On the other hand, X-Efficiency theory of Leibenstein (1978) view slack as wasteful and incompetence of business units. These two views of theories would maintain that slack should be reduced and if possible eliminated.

Reconciling the behavioral theory of the firm and economics, it is interesting to note that slack can be a blessing and a curse, implying the presence of curvilinear relationship between slack and performance. The advocates of slack (a behavioral theory of the firm) maintained that slack as a resource facilitating proactive strategic actions and thereby increasing performance (Daniel et al., 2004). In contrary, those who assume slack as idle resources denotes for inefficiency (X-Efficiency (Leibenstein, 1966; theory of the firm of Jensen & Meckling, 1978) and diminish long term organizational performance. This inefficiency paradigm also posits that slack can encourage satisfying or self-serving behavior that hurt performance. For instance, Jensen and Meckling (1978) and Jensen (1986) maintained that the presence of excess resources may enhance the managers tendency to pursue self-serving projects.

It is therefore, interesting to figure out whether there is a “curse” in both the economics and behavioral perspectives. In this vein, organization must have excess resources to absorb for the unforeseen contingencies but not too much so that preventing the self-serving behavior of the managers.. Therefore, this study predicts that *the relationship between slack and performance is inverted U-Shaped*.

METHODOLOGY

The population frames of current study, where the source of data were gathered, were from several sources. Corporate parents' annual reports and Indonesian Capital Market Directory (ICMD) 2006 & 2007 were used to identify the number of business units being controlled and firms-specific financial attributes. ICMD periodically published a concise public firm's financial statements. Firm's annual reports were then utilized to identify the business units. Another set of directory that was used in this study is Indonesian Manufacturing Industry Directory (IMID) that is issued periodically. This directory was useful in identifying addresses, primary products and employment of business units. The total manufacturing companies per December 2006 is 20,890 companies.

In order to ensure the validity of the findings, the study restricts the sampling procedure into a subsidiary of a corporate with a 50% ownership minimum and must at least own two subsidiaries. Therefore, this study was conducted at the business units' level in order to understand the ways, effectiveness and appropriateness of control and monitoring activities placed by the corporate parents.

The cover letter involving questionnaires were sent via mail (in stamped addressed envelope) directly to the top and middle level manager in a respective business unit since they are the ones that have considerable contact with the corporate. The cover letters also assured that there would be no responses attributed to any individual or business unit, and only statistical, summary data from the total responses from several business units would be published.

The questionnaires were developed using 6 item Liker scale. The use of six items Likert scale has been commonly employed in social sciences and in fact, may result in greater efficiency and reliability (Chang 1994). A study conducted by Infosurv (2006) and CICIES (2007) indicates that some respondents prefer the 6-items Likert Scale because the respondents have to commit to either positive or negative values, without any neutral point.

Operationalization of Variables

Organizational Slack

Business units' slack, in this study, is conceptualized as the excess of actual or potential resources that could assist the organization to absorb the environmental pressures and shocks (Bourgeouis, 1980). This variable is a multidimensional constructs consist of two dimensions: financial (business units' slack and budgetary slack).

Financial slack represents the extent to which the organizations have the access to the resources to be further utilized during unexpected shocks or take immediate actions for the emergent opportunities (Martinez & Artz, 2006). With regard to this financial slack, agreement has been reached pertaining to its operationalizations. Usually, it consists of available slack, potential slack and recoverable slack. For these variables, two steps were employed. The study use archival, objective measures of business units slack generated from annually financial statements and/or annual report. If these data were not available,

survey method will be conducted. Business units managers will be asked to indicate the amount of slack (proxied by several financial ratios) in their business units. If both data are available, objective measures will be used since there is no social obligation from managers to report good results thereby increasing the validity of the data.

Financial slack is measured using three indicators: 1) available slack that is determined according to current ratio (i.e. current assets/current liabilities) which a reflection of organizations' resources availability on terms of liquid assets that can be used as a buffer from the negative implications of environmental shocks (Herold et al., 2006). Current assets in this study are simply defined as the assets that can be easily converted into cash within a short time. It consists of cash, marketable securities, receivables, inventories and other short term assets. Current reliabilities on the other hand is the financial obligations that have to be settled within a short period of time. 2) potential slack, that is defined as the firm's ability to have new capital resources through debt borrowings (Martinez & Artz, 2006). Following Palich et al. (2000) and Simerly and Li (2000) suggestions, this study measures potential slack as debt-equity ratio**.** 3) recoverable slack, that is also known as absorbed slack, is the extent to which resources are embedded in firms as excess costs but could be recovered through when firms experience financial difficulty (Singh, 1986). Following Geiger and Makri (2006), recoverable slack is measured by selling, general and administrative expenses divided by sales**.**

Budgetary slack, on the other hand, is defined as manager's likelihood to set the budgets lower by underestimating the budgeted revenues and overestimating the budgeted costs so that the budget targets becomes easier to achieve. (Lukka, 1988). This variable was measured by Dunk (1993) and Stede's (2000; 2001) measurement consists of 5 items (items 1-4, using 6 items Likert's scale from strongly disagree to strongly agree, and item 5 is fully anchored question asking whether the budget is very easy to attain until impossible to attain). Following Stede (2001, p. 41), the questionnaires include: 1. Succeed to submit budgets that are easily attainable; 2. Budget target induce high productivity in my business unit (reverse coded); 3. Budget target requires cost to be managed carefully in my business unit; 4. Budget target have not caused me to be particularly concerned with improving efficiency in my business unit; and 5. a fully anchored question: "My Business unit budget is…" from very easy to attain to impossible to attain

Performance

Current study adopted two widely used of financial performance, which are Return on Assets, Return on Equity, operating profit and sales growth. Moreover, subjective measures of business unit performance were also employed. Using financial, objective measures of performance will increase the likelihood the presence of 1 or more year lag relationship between slack and performance. For instance, slack resources may not affect the performance on its current year, but it probably affects performance on its 1 or more year a head. While subjective, non-quantitative measures of performance are created using the measurements of Birkinshaw et al. (2005). In this vein, the performance of business units managers are evaluated, relative to other business units, on the basis of their productivity, quality, supplier relationships, labor costs, productivity improvements, technology and

customer development on a six point scale, ranging from 1=significantly worse than competitors, and 6 = significantly better than competitors.

Data Analyses

Structural Equation Modeling (SEM) was employed in this study for several reasons. First, SEM allows the analysis of multiple relationships simultaneously that cannot be conducted by other conventional multiple regressions analyses. Thus, SEM accounts for the presence of structural errors. Ignoring these errors may lead to the specification errors affecting validity of the results. Second, SEM provides measures of overall model fit. These measures were important to figure whether the model is acceptable given a particular data. Third, and most importantly, SEM explains the significance of each relationship between the variables hypothesized. SEM also allows for testing the indirect effects between variables. Fourth, unlike regression models and path analysis, SEM may account for the effects of measurement errors in multi-item variables (constructs). Since constructs were measured using multiple indicators, it is unreasonable to assume that these constructs are error-free, and instead, there are potential errors in those indicators.

In testing the non-monotonic relationship of the hypothesis, this study adopts an approach suggested by Ping (2004, 1995) and Cohen et al. (2003) involving two steps. In the first step, the measurement model is evaluated by Confirmatory Factor Analysis. The measurement model assessed whether all items in a given scale represented the same latent factor. Second, the structural model then examined to ensure whether the variables hypothesized were fit. On the next step, an estimation technique is proposed for quadratic latent variables in structural equation modeling specifying these quadratic latent variables with a single indicator (Ghozali & Fuad, 2004). With regard to this single indicator approach, the quadratic product (*x:x*) of slack is specified as $[x_1 + x_2 + \ldots + x_n]^2$. The loadings ($\lambda_{x:x}$) are given by $[\lambda_{x1} + \lambda_{x2} + \ldots + \lambda_n]^2$ and measurement errors ($\theta_{x:x}$) are fixed by $[4(\lambda_{x1} + \lambda_{x2} + \ldots + \lambda_n)^2$. VAR(X). $(\theta_{\varepsilon.x1} + \theta_{\varepsilon.x2} + \ldots + \theta_{\varepsilon.xn})$. As been suggested by Anderson and Gerbing (1988), use of a measurement model must be separated from model structure issues. Therefore, besides using the measurement model to ensure unidimensionality of the constructs, parameter estimates from a linear-term measurement model can be used to compute the values of $\lambda_{x:x}$ and $\theta_{x:x}$ (fixed loadings and fixed errors, respectively). This approach may eliminate the substantial differences in the estimated parameters of measurement models and structural models (Ping, 1995).

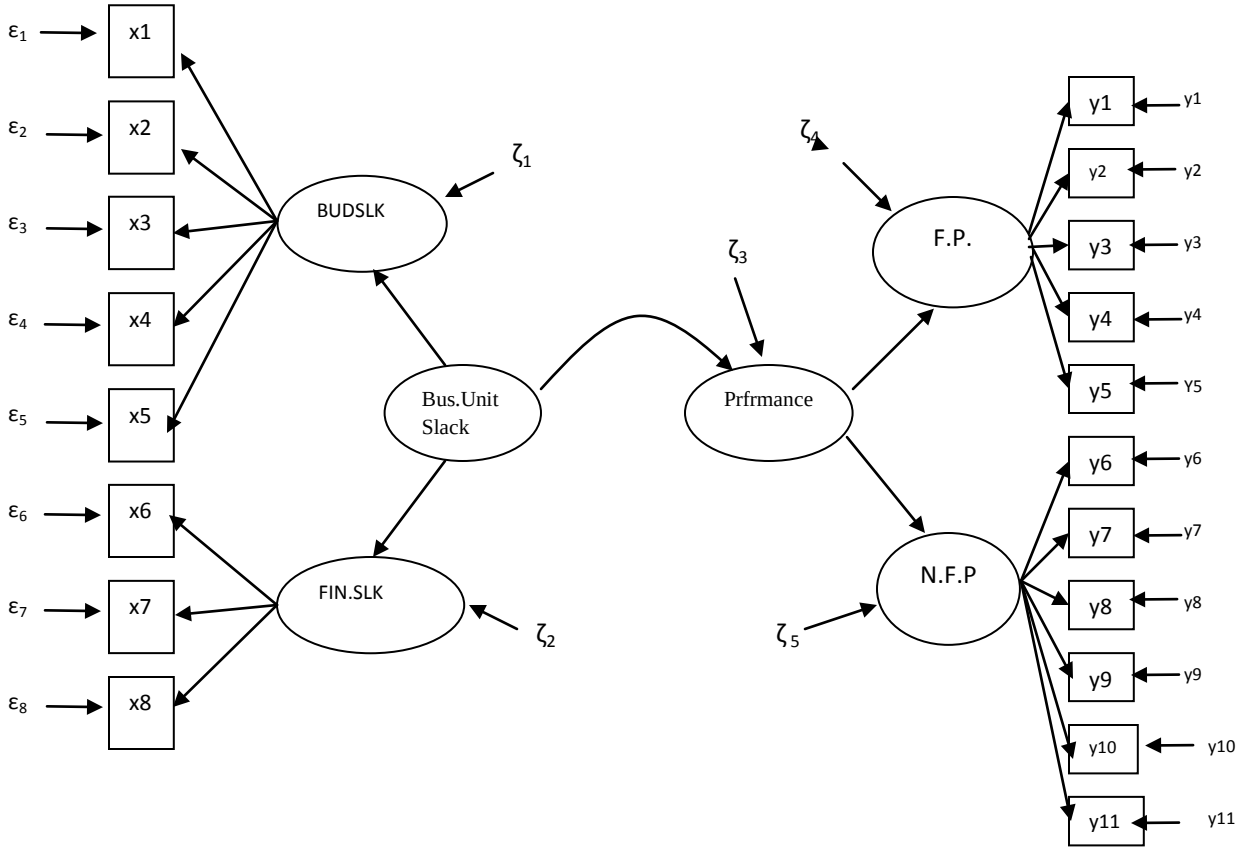

Figure 1: the structural model of second order performance outcome of business units' slack.

This model is estimated using this polynomial technique by (1) estimating the measurement model parameters, (2) calculating the equations above to generate the loading ($\lambda_{x:x}$) and error variances ($\theta_{x:x}$) for the quadratic latent variable, and (3) estimating the structural model with the fixed values of $\lambda_{x:x}$ and $\theta_{x:x}$. This method employed Linear Structural Relationship using Maximum Likelihood approach. This procedure requires mean-centered indicators for both exogenous and endogenous latent variables, which is created by subtracting the indicator's mean with its each value in the data set per case (i.e. $[x_i - \mu_x]$; where x_i denotes for observation *i-th* of *x* manifest variables and μ_x denotes for mean of a particular manifest variable *x*). the model fit was tested by several indices. Table 2 portrays important indices and their respective cut-offs.

RESULTS

The profile of business units are clearly portrayed in table 5.6. Business units with public-listed corporate parent comprise 55% of the sample while the remaining 45% are business units with non-public listed corporate parent. Regarding the size of the firm (in terms of average sales), sixty seven business units are considered large as they earn more than Rp 10 billion on sales, fifty one are considered medium as they make Rp.5-10 billion sales while seventeen are regard as small since their average sales are less than Rp 5 billion. Regarding the types of the business units, seventy five business units are local based-company seeing that their products are aimed for local markets, while sixty business units are multi-national company. Regarding the business units tenure, eighty one business units have been in operation for more than ten years, while fifty three business units have been in operation for 6-10 years.

Pertaining to the production type, fifty one business units engage in food and beverages industry, thirty one in textile mill products, twenty nine in lumber and wood products, and twenty three business units enroll in chemical and allied products. Regarding the focus of their market, forty five business units focus on local market and twenty one business units focus on export market. Sixty nine business units focus on both local and export market. All of the respondents reveal that they are involved in the budgeting process, but only sixty nine of one hundred thirty five receive full autonomy from the corporate parent, while the remaining sixty six business units hold no/partial autonomy.

Table 2: Business units' characteristics.

	Frequency	Percent
Corporate Status		
- Public Listed	74	54.8
- Non-public listed	61	45.2
Type of Business Units		
- Local based Company	75	55.6
- Multi-national Company	60	44.4
Business Units Tenure		
- 1-5 years	1	0.07
- 6-10 years	53	39.3
- More than 10 years	81	60
Production Type		
- Food and Beverage	51	37.8
- Textile Mill Products	31	23
- Lumber and Wood Products	29	21.5
- Chemical and Allied Products	23	17
- Others	1	0.07
Type of Products		
- Consumer products	77	57
- Industrial products	52	38.5
- Both or others	6	4.4
Autonomy		
- Full Autonomy	69	48.9
- Partial/No autonomy	66	51.1

The result of Confirmatory Factor Analysis (CFA) in the first step is conducted in order to calculate the fixed loadings and error variances for the second step are portrayed in table 3. The results below did not used for measurement models testing. Rather, this step is conducted in order to uncover the fixed and constrained values for the single indicator of quadratic latent variables of financial and budgetary slack.

Table 3: *First step of Ping (2004) approach in non-linear Structural Equations Modeling.*

Items	Loading	Errors	R^2
BUDSLK1	0.39	0.84	0.16
BUDSLK2	0.55	0.69	0.31
BUDSLK3	0.38	0.85	0.15
BUDSLK4	0.39	0.85	0.15
BUDSLK5	0.40	0.84	0.16
CRT	0.21	0.96	0.04
DERT	-0.31	0.90	0.1
SLEXT	0.38	0.86	0.14

Applying the generated loadings to $[\lambda_{x1} + \lambda_{x2} + \ldots + \lambda_n]^2$ yield the constrained loadings for budgetary slack of 2.01 and financial slack of 0.1296. Furthermore, applying the generated error variances to $[4(\lambda_{x1} + \lambda_{x2} + \ldots + \lambda_n)^2$. VAR(X). $(\theta_{\varepsilon.x1} + \theta_{\varepsilon.x2} + \ldots + \theta_{\varepsilon.xn})$ yield constrained error variance about 73.528 for budgetary slack and 1.399 for financial slack. Thus, the measurement model for non-linear outcome performance equation is:

$$\begin{Bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \\ x_8 \\ x_9 \\ x_{10} \end{Bmatrix} = \begin{Bmatrix} \lambda_{x1.1} & 0 & 0 & 0 \\ \lambda_{x2.1} & 0 & 0 & 0 \\ \lambda_{x3.1} & 0 & 0 & 0 \\ \lambda_{x4.1} & 0 & 0 & 0 \\ \lambda_{x5.1} & 0 & 0 & 0 \\ 0 & \lambda_{y1.2} & 0 & 0 \\ 0 & \lambda_{y2.2} & 0 & 0 \\ 0 & \lambda_{y3.2} & 0 & 0 \\ 0 & 0 & 4.4944 & 0 \\ 0 & 0 & 0 & 0.1296 \end{Bmatrix} \begin{Bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \end{Bmatrix} + \begin{Bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta \\ \delta_6 \\ \delta_7 \\ \delta_8 \\ 73.528 \\ 1.399 \end{Bmatrix}$$

The constrained error variances and loadings generated then used to calculate the non-monotonic relationships hypothesized in this study. The results are depicted in table 4. The results indicate that there is an inverted U-shaped ($\cap$) relationship between financial slack and financial performance (γ = -0.027, t = -6.90). However, the proposed inverted relationship between financial slack and non-financial performance cannot be accepted (γ = -0.0035, t = -1.18).

Table 4: Results of Non-linear Structural Equations Modelings.

The Effect of…	To…	Estimates	t-values
Financial Slack	Financial Performance	0.73	7.37*
Budgetary Slack	Financial Performance	-0.25	-2.45*
Financial Slack^2	Financial Performance	-0.034	-6.96*
Budgetary Slack^2	Financial Performance	0.0082	1.02
Financial Slack	Non-Financial Performance	0.28	3.84*
Budgetary Slack	Non-Financial Performance	0.52	6.39*
Financial Slack^2	Non-Financial Performance	-0.0043	-1.15
Budgetary Slack^2	Non-Financial Performance	-0.0061	-7.90*

Interestingly, this study found that there is no quadratic effect of budgetary slack to financial performance (γ = 0.002, t = 1.10), but hinted the presence of non-linear relationship ($\cap$) between budgetary slack and non-financial performance (γ = -0.013, t = -7.90).

The results can also be elaborated to figure-out the optimum level of slack. For instance, the results above indicate that there is a non-linear relationship between financial slack and financial performance. For a simple non linear function of $Y = b_1 X + b_2X^2 + e$, the maximum value of vertex (peak value of the parabolic graph) would be $-b_1/2b_2$. Kindly recall that the non-linear structural equation function is FP = 0.73*FS + -0.034*FP+0.28 therefore, the maximum value of the vertex would be = 0.73/(2*-0.034). The graph below visualizes the non linear relationship between financial slack and financial performance.

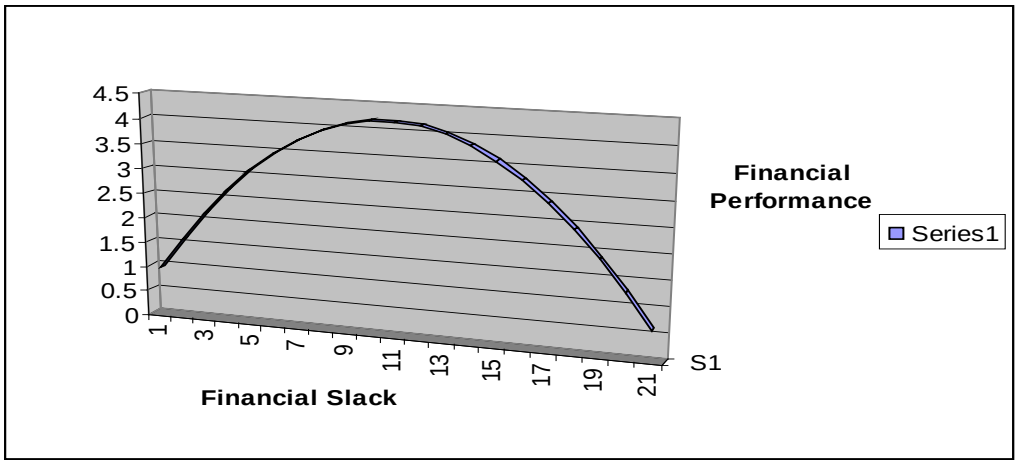

Figure 1: The non-linear relationship between financial slack and financial performance.

DISCUSSION

This study cannot test the effect of higher order business units' slack to higher order overall performance as the model did not fit well with the data. Rather, this study examines the non-

monotonic impacts of lower order exogenous variables of business units' slack (e.g. financial and budgetary slack) to lower order endogenous variables of performance (e.g. financial and non-financial performance). The acceptance or rejection of the hypothesis therefore, is based on this assumption.

This study found that there is a non-monotonic relationship between financial slack and financial performance. In particular, this study found that the relationship between financial slack and financial-performance is inverted U-Shaped. It means that the relationship between financial slack and financial performance is positive, until it reaches the peak point and then turn to negative. Hence, it signifies that there is a "curse" in both very few financial slack and too much financial slack pertaining to its effect with financial performance.

This non monotonic (∩) relationship implicitly concurs with several arguments on the slack-performance relationships (Latham & Braun 2008; George, 2005; Tan and Peng, 2003; Nohria and Gulati, 1996). This finding substantiates the joint roles of behavioral theory of the firm as well as economist perspectives. The behavioral theory of the firm argues that slack as good and may increase the innovative ideas and to absorb the shock of environmental turbulent and thus may increase the firm's financial performance. After some level, based upon the perspective of economist, too much slack may inhibit the innovative ideas as there is a great chance that the business units will be investing in pet-, non productive projects, and therefore may inhibit financial performance.

However, it is interesting to figure out that the alternative hypothesis of the non-linear effect of financial slack to non-financial performance cannot be accepted. One main possible explanation for this failure is probably due to the presence of lag effect financial slack to non-financial performance. In particular, the presence of financial slack may not directly affect the non-financial performance in a timely manner, rather, it is plausible that the effect can only be seen within the next few years a head. Or simply stated, current financial slack may impinge on future non-financial performance (e.g. productivity, product quality, supplier relationship, productivity improvement, technology, customer development and labor cost). However, this speculation cannot be further tested as this study is cross-sectional in nature and such longitudinal data are very hard to attain. The use of objective, pure quantitative data may also be blamed for such a finding.

Furthermore, the result of this study indicates the rejection of the alternative hypothesis regarding non-monotonic relationship between budgetary slack and financial performance. Rather, this study found the negative, linear effect of budgetary slack to financial performance. Several arguments are offered regarding the non-acceptance of non-linear effects of budgetary slack ton financial performance and acceptance of negative linear effect of budgetary slack to financial performance. First, the sample of this study is the business units that are held accountable on terms of the cost spent and revenues generated, or simply stated the samples were profit centers of the corporate parents. With this regards, the slack creation during the budgeting process implicitly means the flexibility, innovativeness and creativeness that are transformed into operating actions that shall yield in short-term profit or performance. Indeed,

there is a possibility that the positive effects of budgetary slack to financial performance may not be exist in the long-run, as they may in fact impair the long-term profitability. Nevertheless, this argument cannot be further tested in this particular finding as longitudinal or pooled, cross-series study should play a major approach for this type of study.

Furthermore, as expected, this study found the presence of non-monotonic relationship between budgetary slack and non-financial performance. This finding indicate that slack creation during the budgeting process yields the intangible performance, but again, too much budgetary slack may in fact impair the stability of the firms' particularly on terms of its intangible performance relative to business unit's performance. This finding apparently solve the intractable debate between "behavioral accountants" (Stede 2000; 2001, Davis et al., 2006; among others) and the economists (so called "theorists of the firm" such as Jensen, 1986; Jensen & Meckling, 1976 among others) regarding the non (discretionary) use of budgetary slack to the performance.

CONCLUSION

The findings of these studies need to be considered in light of several limitations. First, the research was confined to a manufacturing industry in Indonesia, and thus generalizations to other industries should be used with extra cautions. It is very plausible that the pattern of relationships between the slack and performance may be different than those found in this study.

In order to provide fruitful findings, as well as robust generalizations of the estimated parameters, further study should consider other industries, particularly in Indonesia. Martinez and Artz (2006), Hendrick (2006), Combs and Ketchen (1999), Hitt et al. (1991), and many others argued that slack requirement may be different among different industries, and thus the reasons and its outcome may be different from one industry to another.

Second, it is necessary to acknowledge the limitation of cross sectional based survey research, as such this study design prevent any test on causal statement on the time series basis. Besides, slack creation can be an accumulation of several periods phenomenon. In particular, the slack creation may not affect the performance in the timely manner, but they may be transformed and require time period to show its real effect. For instance, slack may affect future performance, instead of current performance. With this regard, future research should also consider the time series properties of the data, particularly on the contextual variables affecting business units' slack and slack outcome to performance.

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4th Parallel Sessions

Thursday June 30, 2011
15:30 – 16:50

A4 – Customer Satisfaction

A4.1 **The evaluation of clinical staff on technology-based service encounter: Technology readiness as a moderator**
Dr. Eng, Cheng Joo

A4.2 **Challenges of launching innovative technology applications through customer projects**
Tuula Lehtimäki

A4.3 **A study of consumer's intention to return the government website on industrial development bureau in ministry of economic at Taiwan**
Yin-Yih Chang

A4.4 **Manufacturing capabilities prioritization to achieve customer focus in knowledge-intensive environments**
Ajmal, Mian M.

THE EVALUATION OF CLINICAL STAFF ON TECHNOLOGY-BASED SERVICE ENCOUNTER: TECHNOLOGY READINESS AS A MODERATOR

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ABSTRACT

Technology-based service encounter (TBSE) is an important role in service industry especially in the area of marketing and consumer behavior. Prior research have mostly focused on the interaction of organization and end-user. This study aimed to examine TBSE adopted by the hospital and validate the moderating effect of technology readiness on the relationships among TBSE towards service quality and perceived value. With paper-based questionnaire, the quality and value of TBSE were evaluated by the clinical staff to understand whether it could meet their needs and desires when serving the patients. Statistical methods such as structural modeling equation (SEM) and hierarchical regression analysis were conducted for data analysis. The results revealed that TBSE has direct effect on both service quality and perceived value; and both of them also have direct effect on satisfaction of using TBSE. Technology readiness was showed to have moderating effect on the relationship between TBSE and service quality but not on TBSE and perceived value. The additional analysis revealed a direct and significant effect on both TBSE and perceived value. From the managerial perspective, staff opinions are important for making decision of implementing or upgrading new technologies. The management should encourage staffs continue learning and exchange their knowledge to use TBSE more completely, ultimately, enhancing the service quality. Manufacturer or provider should pay more attention to the feedback from institutes and establishing a tight relationship to develop good impression and enhance satisfaction of the staffs.

Keywords: Technology-based service encounters (TBSE); service quality; perceived value; technology readiness

INTRODUCTION

Service encounters are very important and crucial for all industries, including those that have not been traditionally defined as service industries such as health care or manufacturing industries (Bitner, Brown and Meuter, 2000). The increasing development of technology is changing the essence of service encounters; hence, many companies or

institutes put an emphasis on how these encounters can be improved through the effective use of technology.

Several studies (e.g., Bitner et al., 2000; Froehle and Roth, 2004; Schumann, Keller, Wangenheim and Holzmuller, 2007) have stressed on the importance of technology and the critical role of technology-based service encounter (TBSE) in service industries. However, studies that indicating TBSE from the viewpoint of healthcare industry is rare. Many scholars have mentioned that service quality is the key of continued improvement in service industry such as healthcare industry (Aga and Safakli, 2007; Piligrimiene, 2008; Yang and Peterson, 2004). Parasurman (2000) indicated technology readiness as a main effect of measuring how much people love technology.

This study aimed to understand the influence of TBSE towards service quality and perceived value, subsequently explored the satisfaction of clinical staff that have experienced technology-based encounters. Technology readiness of clinical staff was considered as a moderator in the study. Therefore, the main objectives of the study was (1) to examine the direct effect of TBSE on service quality, and the perceived value; (2) to further examined the direct effect of service quality and perceived value on satisfaction of clinical staff who have experienced technology-based service encounter; and (3) to examined the moderating effect of technology readiness on the relationships among TBSE, service quality, and perceived value.

THEORETICAL BACKGROUND

Technology-based Service Encounter

Nowadays, TBSE plays an important role in miscellaneous fields, especially in service industries. Froehle and Roth (2004) define TBSE as service providers delivering information to receivers via a technological interface in order to allow for an immediate information exchange between receivers. Technology-based service, can be restored, customized, served long distance, and provided automatically (Schumann et al., 2007), brings changes to record keeping process for both clinical staff and the patients in health care institutes. Abdolrasulnia, Menachemi, Shewchuk, Giner, Duncan and Brook (2008) indicated that the medical quality of doctors will improve when hospitals have well installed technology-based equipment. Meanwhile, other researchers believe that suitable technology-based products such as electronic medical records (EMRs) can reduce paperwork and medical errors (Li, Bahensky, Jaana and Ward, 2008). Schumann et al. (2007) stated that TBSE allow the provision of consulting services in a technology-mediated interaction process between clinical staff and the patients in hospitals.

The usefulness, easiness to use of the technology product/service will be evaluated by the clinical staff to determine whether it is useful, accessible, controllable, and beneficial to them. They will also assess whether the EMR system can save time as well as storing the correct consultation record (Froehle and Roth, 2004). Technology undoubtedly brings advantages to the users; however, the complexity and compatibility of the technology are always the issue (Menachemi, Chukmaitov, Saunders and Brooks, 2008). User attitude and technology readiness toward new technology are the determinants of implementing information system in healthcare setting (DelliFraine, Dansky and Rumberger, 2006). As

above, the study defines technology-based service encounters (TBSE) as "the clinical staff perceived the technologies are useful, accessible, and beneficial service via technological interface which allows for immediate exchanges of medical information between all clinical staffs and patients through modern communication and medical IT."

Service Quality

Service quality is consisted of several dimensions by scholars such as the two-dimensional models: technical and functional quality (Grönroos, 1984), process and outcome quality, including physical, interactive, and corporate quality (Lehtinen and Lehtinen, 1991); the three dimensional model: interaction, physical environment, and outcome quality (Brady and Cronin, 2001); the SERVQUAL model: tangible, reliability, responsiveness, assurance, and empathy (Parasuraman, Zeithaml and Berry, 1985), and etc.. However, these dimensions are overlapping with each others in some ways.

Parasuraman et al. (1998) argued that service quality is an elusive and indistinct construct that not easy for customers to define. According to Shonk and Chelladurai (2008), service quality can be defined as the differences between what is expected from each of the service dimensions and what a user perceives he or she receives from them. In hospital, quality is regarded as something related to benefits, mostly concerns with how much patients gain or loss from the hospitals, but do not mention about the gain or loss of clinical staff from the new technological equipment. Evaluated health care service quality from the patient's perspective, Piligrimienė and Bučiūnienė, (2008) indicated that many efforts have been made for developing a thorough and generally applicable definition of health care service quality. Dabholkar (2000) defined health care service quality as "the kind of care which is expected to maximize an inclusive measure of patient welfare, after one has taken account of the balance of expected gains and losses that attend the process of care in all its parts." However, clinical staffs also evaluate the real service quality of the latest TBSE with regard to themselves and the patients' concerns.

The American Medical Association identify that some specific attributes of care such as health promotion and disease prevention should be included in the examination quality. Those are the criteria help clinical staff to evaluate service quality of a new technology-based product/service by assessing its stability and improvability. Health care quality is to reach the desired objectives using a legitimate means, where the desired objectives imply the achievable level of health (Piligrimienė and Bučiūnienė, 2008). Thus, health care quality is attained when a physician helps the patient to reach an achievable level of health properly. The service quality of a technology-based product is the key factor influencing patient's needs, as well as an evaluation factor for hospital staff.

The SERVQUAL model by Parasuraman et al. (1985) is adopted for measuring the service quality of hospital in this study. The five dimensions are: "tangibles of technology-based service encounters", which means physical facilities, equipment, and appearance of personnel; "reliability of technology-based service encounters" is defined as the ability to perform the promised service dependably and accurately; "responsiveness of technology-based service encounters" is regarded as the willingness of manufacturers to provide prompt services for the customers; "assurance in technology-based service encounters"

means the knowledge level and courtesy of manufacturers' employees; and "empathy of technology-based service encounters" is the caring, individualized attention that the manufacturers provide to its customers.

Accordingly, this study defined service quality as the belief on the part of clinical staff that the provision of TBSE for the hospital is tangible, reliable, responsive, and has assurance and empathy.

Perceived Value

Cengiz and Kirhbir (2007) pointed out two important characteristics of hospital perceived value by the receivers (e.g., doctors, nurses, or other clinical staff). At first, the use of equipment, such as a technology-based product (e.g., X-ray machine) which differentiates it from personal or organizational values, is inherent. Second, it is perceived by receivers, and cannot be determined objectively by the manufacturers (Cengiz and Kirhbir, 2007). Only the clinical staffs in hospitals are able to perceive the actual value of the products or services offered. This value has been variously conceptualized as customer utility, perceived benefits relative to sacrifice, psychological price, worth and quality (Woodruff, 1997). Furthermore, perceived value varies depending on the types of technology-based products or services and on the personal characteristics of clinical staff in hospitals. Healthcare industries should make an effort to detect the most value perceived attributes that could attract and retain customers.

Zeithaml (1988) defined perceived value as the customers overall assessment of the utility of a product, based on perceptions of what is received and what is given (p.14). Woodruff (1997) also indicated that receivers may perceive value differently at different time such as the stage of purchasing and during or after using a product or service. With this notion, Woodruff developed a customer value hierarchy model; consumers may desire a certain value (desired value), and may evaluate a product or service after they have experienced it (received value). Perceived value has its root in the equity theory, which takes the ratio of a receiver's outcome/input to that of the service provider's outcome/input into consideration (Cengiz and Kirhbir, 2007). As a consequence, this study defined perceived value as the clinical staff overall assessment of using technology-based product adopted by the hospital based on their perceptions of what they benefit from the system and what they could give to the patients via the technical service.

Satisfaction

Satisfaction is the critical outcome to a service encounter because a high level of satisfaction can bring positive word-of-mouth (Wixom and Todd, 2005) and relationship quality. In hospitals, when clinical staffs have higher satisfaction of using a new technology-based product/service, they will have positive perception about the manufacturer. Meanwhile, Customer satisfaction is an emotional response that resulted from a cognitive process of evaluating the service received against the costs of obtaining the service (Tam, 2004). Aga and Safakli (2007) define satisfaction as "the receivers judge that a product or service feature, or the product or service itself, provides a pleasurable level of consumption-related fulfilment, including levels of under or over-fulfilment." In a service context, overall

satisfaction is similar to overall evaluations of service quality (Gustafsson, Johnson and Toos, 2005). As a performance measure, satisfaction is considered an important outcome in healthcare industries. Service quality and satisfaction are in common in many ways, but they can still be distinguished. Satisfaction is generally viewed as a broader concept, while service quality assessment focuses on dimensions of service (Akter, Upal and Hani, 2008).

According to Zviran and Erlich (2003), receiver satisfaction is an important criterion for measuring the success of technology-based products/systems; they define satisfaction as the degree to which receivers believe the new technology-based system at their disposal is fulfilling their needs. An exploratory study on the correlation of receiver satisfaction with computing conducted by Chang (2010) found that there are significant and positive relationships between receiver satisfaction and hardware or software accessibility and availability, the receivers' computer background, attitudes toward computing, and system utilization. Besides, the studies such as Lin and Shao (2000), Staples, Wang, and Seddon (2002) mentioned that customer participation, attitude, involvement as well as expectation of TBSE show a significant relationship with customer satisfaction. Zviran and Erlich (2003) pointed out customer satisfaction is an important elements of measuring technology product/ service success.

Chakrabarty, Whitten, and Green (2007) defined satisfaction as the sum of feelings resulting from receivers' beliefs regarding the extent to which a technology meets their requirements. This study adopted three scales: time information product, knowledge, and involvement to evaluate receiver satisfaction in the hospitals. The "time" scale measures the degree to which the administrators can wait for developing a new system in a hospital. The "information product" scale measures the reliability, relevancy, accuracy, precision, and completeness of the output information. And the "knowledge and Involvement" scale measures the degree of technical training provided to receivers in the hospital, the degree to which receivers understand and have positive or negative participating feeling on the systems (Chakrabarty et al., 2007).

As a consequence, this study defined satisfaction as a sum of feelings of the clinical staff about using a technology product / service adopted by the hospital and evaluated by the time, product information, knowledge and involvement scales."

Technology Readiness

Technology readiness has been applied in a variety of fields such as consumer marketing, online service, educational fields, and health care industries. Parasuraman (2000) stated that technology readiness is the degree to which people love or embrace a new technology to achieve their goals. He also claimed that people who have adopted advanced technologies earlier than others will take using cutting-edge technology-based products for a normal thing. In other words, these people usually demonstrate a strong desire to absorb new technological products into their lifestyles.

Several studies suggested that as the differences in the psychographic profiles of technology adopters are discovered, hospitals need to determine the different levels of technology readiness within the staff and divided the low level into four groups – displaying optimism,

innovativeness, discomfort, and insecurity (Lin and Hsieh, 2006; Parasuraman, 2000). Displaying optimism means the people who have positive attitudes toward new technology and believe in the benefits will come along with new technology. Therefore, in the case of TBSE, this group is made up of positive individuals who can see it as a fresh experience. Innovativeness as the clinical staffs in hospitals have willingness to learn new technology due to the decrease of administrative errors and time consuming reduction for paperwork, regarding themselves as innovators and leaders who will head up the trend to try new technology as a fad. Discomfort is individuals who have negative attitudes towards new technology and avoid using it in a workplace full of technology-based equipments. They perceive these equipments as unnecessary and inappropriate for junior members to use. Insecurity is those who totally dislike new technology and believe that it have made their daily life more complicated and more troublesome. As to the connection between TBSE and technology readiness, Parasuraman (2000) pointed out that people generally have positive or negative attitudes toward technology-based services or products based upon their need, evaluation or acceptance. This study defined technology readiness as the degree of preparation of the clinical staff for the technology-based products/services adopted by the hospital.

Conceptual Framework

Figure 1 below illustrated the conceptual framework. The model represented that TBSE had direct effect on service quality and perceived value, and both service quality and perceived value subsequently affected satisfaction. The dimensions of service quality were labelled as tangible, reliable, responsiveness, assurance, and empathy. And satisfaction included three dimensions: time, product information, and knowledge and involvement. Technology readiness was adopted as a moderating role that moderated the relationship between TBSE and both service quality and perceived value.

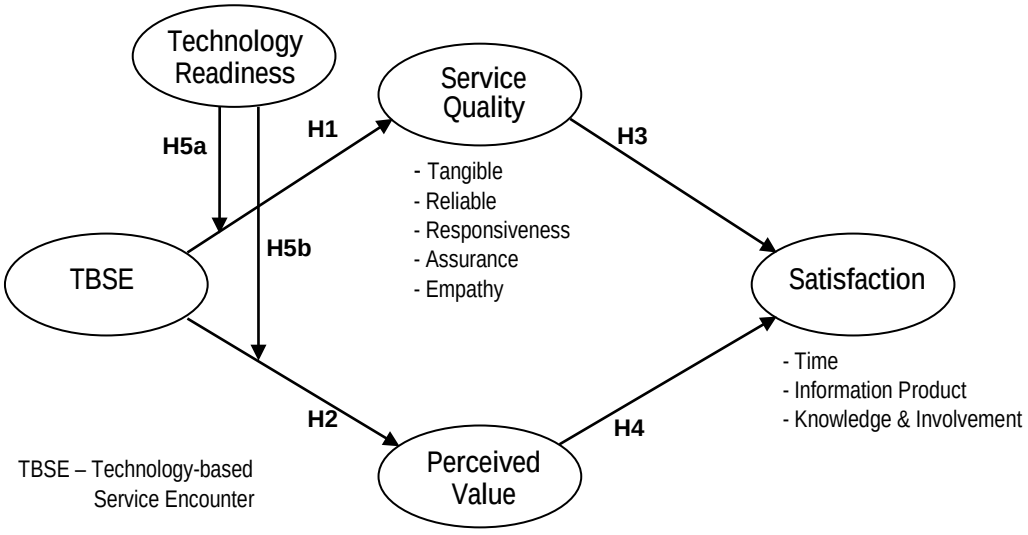

Figure 1: Conceptual Framework.

Hypotheses Development

Technology-based Service Encounters and Service Quality

Parasuraman et al. (1998) indicated two different service styles, personal and technological services, which people would judge them by their own expectations and evaluations of service experiences. According to Bitner et al. (2000), infusing technology into the service encounter would generate a high level of a great satisfaction, such as customization, spontaneous delight, and service recovery. It infers that there is a positive relationship between TBSE and higher degrees of satisfaction.

Chang and Chang (2008) conducted a study on the receivers' preferences and evaluations of TBSE in hospitals and found that different receivers held different opinions and perceptions about the TBSE. They also indicated that the overall evaluation of the TBSE quality was based on the receiver attitudes toward the technology-based service and the demands for interaction between the receivers and providers. It reveals that when clinical staff in a hospital that had a positive attitude toward TBSE (equipment) would have optimistic attitude about receiving it. Parasuraman (2000) pointed out that the positive influence on TBSE towards service quality of hospital was building higher entry barriers, enhancing of productivity, and an increase in profits. Therefore, in most of service industries, TBSE plays an important role in remaining competitive. Following the above discussion, the study proposed the hypothesis 1 as below:

H1: The adoption of technology-based service encounters designed to serve patients can positively increase the service quality of clinical staff.

Technology-based Service Encounter and Perceived Value

Perceived value on TBSE (equipments) was regarded as a personal experience and judged by the TBSE (equipments) using experience by the clinical staff. The positive or negative perception of the TBSE (equipments) is likely depending on the clinical staff attitude and experience toward it.

Additionally, perceived value of the attitude toward the use of new TBSE (product/service) would bring high or low satisfaction with the facilities involved. Tam (2004) defined perceived value as the degree of service quality from the clinical staff in hospital or health care centre. It revealed that the clinical staff of hospital or health care centre staff care about the service quality provided to their patients, when the perceived value toward a technology-based product/service is positive, they will have more satisfaction. Hence, this study proposed the following hypothesis:

H2: The adoption of technology-based service encounters designed to serve patients can increase positive perceived value of clinical staff toward the technology.

Service Quality and Satisfaction

In recognition of the expanded role of the technology-based system department and the importance of technology-based products/services, researchers have begun to include service quality as a measure of satisfaction or success in recent years (Zhu, Wymer and Chen, 2002; Brown and Chin, 2004). Oliver (1980) stated that service quality can influence receiver satisfaction not only directly via receiver observation, but also indirectly via an input to the disconfirmation comparison (e.g., discrepancy between performance and expectation). Parasuraman et al. (1985) proposed that a higher level of service quality can increase receiver satisfaction. Several studies have also acknowledged receiver satisfaction is positively connected with the level of service quality that delivered by the service providers (Host and Andersen, 2004; Saravanan and Pao, 2007). Accordingly, it can presume that service quality is significantly related to receiver satisfaction.

McDougall and Levesque (2000) studied the service domains of dentists and other industries in Canada and concluded that core service quality will drive receiver satisfaction. When clinical staff satisfy the modern software or hardware with the technology-based equipments, they are more likely to accept the waiting time of adopting the new system. Moreover, clinical staff will be more satisfied when the manufacturers show a sincere interest in solving problems, perform professionally with necessary knowledge, as well as customize necessary technology for the hospital. These can enhance the clinical staffs' confidence and perception on the manufacturers, and ultimately facilitate their satisfaction. Based on the discussions above, it can be asserted that there are positive relationships between service quality and satisfaction. Hence, this study made the following hypothesis:

H3: The increase in service quality can positively increase clinical staffs' satisfaction toward technology.

Perceived Value and Satisfaction

Fornell and Larcker (1981) identified perceived value is the main driver of overall receiver satisfaction. Meanwhile, McDougall and Levesque (2000) concluded that perceived value is a significant factor and has impact on work loyalty entirely through receiver satisfaction. According to Yang and Peterson (2004), perceived value is the ratio of the benefits received from providers relative to the costs sacrificed by receivers. Tam (2004) indicated that the value of the technology-based equipment which perceived by the clinical staffs in hospitals or health care industries is the pivotal determinant of their satisfaction. Once the clinical staffs perceive greater value than the actual cost of the TBSE (equipments), such as it brings more benefit to the patients, which in turn results in higher satisfaction.

On the basis of the behavioural model toward perceived value and satisfaction, the perceived value effect is significantly influenced by the cognition of the clinical staff in hospitals. According to Tam (2004), received-perceived value in health care industries has a positive effect on receiver satisfaction. Based on the discussion above, the study infers there is a positive relationship between perceived value and satisfaction. Therefore, the following hypothesis was purposed:

H4: The increase in perceived value can positively increase the satisfaction of clinical staff toward technology.

Moderating Effect of Technology Readiness

From the perspective of TBSE, Mick and Fournier (1998) mentioned that people sometimes hold two conflicting thinking in their mind, they pointed out eight technology paradoxes (control vs. chaos, freedom vs. enslavement, new vs. obsolete, competence vs. incompetence, efficiency vs. inefficiency, fulfilling vs. creates needs, assimilation vs. isolation, and engaging vs. disengaging) to explain different values, needs and acceptance are the keys to determine or affect a person's thinking. DelliFraine et al (2006) claimed that some of the nurses regard technology as an additional task but some regard it as a positive benefit. It is obvious that different level of technology perception and the ways people work will affect the quality of TBSE.

In addition, different background of clinical staff including doctors, nurses, and medical administrators have different perception as well as technology readiness on new technology, which in turn affecting the attitude and satisfaction with such new technology when applying it. According to Cengiz and Kirkbir (2007), perceived value has been variously conceptualized as receiver utility, which is related to the psychological price, worth and quality. As above, technology readiness can be regarded as an overall thought of individual to determine whether he or she is eager to use a new technology (Parasuraman, 2000). For instance, when the clinical staff in hospitals are ready for the technology-based service adopted by the hospital and perceived it as easy, useful, and beneficial, they will have a positive attitude towards the service quality. Thus, there may have a positive or negative relationship between TBSE and service quality in certain level. As a consequence, this study proposed two hypotheses as following:

H5a. Technology readiness of clinical staff has a moderating effect on their use of TBSEs and the service quality toward technology.

H5b. Technology readiness of clinical staff has a moderating effect on their use of TBSEs and the perceived value toward technology.

RESEARCH DESIGN

A quantitative research design was adopted by this study. The questionnaire was based upon seven-point Likert style which ranged from "Strongly Agree" to Strongly Disagree". A total of 45 measurements were modified from the previous studies with the relevant definitions. The definitions of each constructs and dimensions were illustrated in Table 1. There were five major constructs as TBSE, service quality, perceived value, satisfaction, and technology readiness to measure the implicit and explicit knowledge of the clinical staff in hospitals.

Table 1: Summary of Overall Model Constructs.

Construct	Description of This Study	Key Citations
Technology-based service encounter (TBSE)	The clinical staffs provide service via technological interface to the patients, which allows for an immediate exchange of medical information between the clinical staffs and the patients through modern communication and medical information technology.	Froehle & Roth (2004), Schuman et al. (2007), Li et al. (2008)
Service quality (SQ)	The belief of clinical staff in the providers of technology product (service) for the hospital is tangible, reliability, responsiveness, assurance, and empathy.	Parasuraman et al., (1998), Aga & Safakli (2007), Sohail et al. (2007), Shonk (2008)
Perceived value (PV)	The clinical staff overall assessment of the utility of the technology-based product adopted by the hospital, based on perceptions of what is received and what is given	Yang & Peterson (2004), DelliFraine et al., (2006); Ekrem & Fazil (2007),
Satisfaction (SAT)	The clinical staffs' sum of feeling on using technology product/service which is adopted by the hospital and evaluated by time, information product, and knowledge & involvement scales.	Chakrabarty et al. (2007), Wixom & Todd (2005), Tam (2004), Akter et al. (2008)
Technology readiness (TR)	The preparation degree of the clinical staff for the technology-based product/service adopted by the hospital.	Parasuraman (2000)

A pilot study was conducted before the formal survey for ensuring the scales' reliability. Cronbach's alpha coefficient was adopted for assessing the interrelationship and internal consistency for each items; the threshold must be greater than 0.70 (Nunnally, 1978). Besides, the assessment of item-to-total coefficient is the Pearson correlation coefficient between the score on the individual item and the sum of the scores on the remaining items. This indicates the degree of an item's relationship to the total score. Item-to-total lowered than 0.50 was subjected to deletion (Weise, 1975). A computer-based questionnaire was distributed via e-mail in mid October 2008. Thirty-two participants responded, two were invalid and the rest were retained for pilot test analysis. As result, Cronbach's alphas of all scales were greater than 0.70, and item-to-total of all items were greater than 0.30. It revealed all measurement scales had steady internal consistency, and all measurement items indicated high degree of item relationship with each constructs.

RESULTS OF DATA ANALYSES

The objective of this study was to examine the attitude toward TBSE of the clinical staff in the hospital. The formal questionnaire was distributed to the health care industries such as clinics, private and public hospitals which providing stable and high quality services. Staff in the hospital are the objects for answering the survey including nurses, doctors, clinical administrators, and etc.. A confirmatory factor analysis (CFA) was conducted for assessing measurement model, structural equation modelling (SEM) for full model; a one-way ANOVA post-hoc Scheffé test analysis was applied for the demographic variables.

Sample Characteristics

The data was collected via paper-based questionnaire, which distributed to the clinics and hospitals including National University Hospital, Presbyterian Church Hospital, the Private Dental Clinic, and etc. in Taiwan from early January 2008 to late February 2009. There were 241 responses to the survey with thirty-five were found invalid. At last, 206 questionnaires were valid for further analysis.

Table 2 illustrated the characteristic of respondents' demographic. It revealed majority of the responses were female (73.8%) and the age was among 20 to 29 (55.3%); most respondents were nurses (51.9%) and had a bachelor's degree (86.4%); 23.3% were from internal medicine department; x-ray machine was the most frequent used technology-based products (16.5%). And lastly, the clinical staff commented that they usually used the technology-based products in the hospitals about 2-5 times each day (33%).

Table 2: Demographic statistics of respondent (N=206).

Item		Freq.	(%)	Item		Freq.	(%)
Gender	Male	54	26.2	Job	Doctor	26	12.6
	Female	152	73.8		Nurse	107	51.9
Education	Bachelor	178	86.4		Administrative	7	3.3
	Postgraduate	28	13.7		Medical Matter	41	19.9
Age	20-29	104	55.3		Assistant	11	5.3
	30-39	96	35.8		Intern	9	4.3
	Above 40	18	19.4		Other	5	2.7
Department	Internal	48	23.3	Product	X-ray machine	34	16.5
	Rehabilitation	17	3.3		Physical therapy machine	14	6.7
	Skin	2	0.9		Thermograph	42	20.3
	Neurology	2	0.9		Dialysis machine	5	2.4
	Pediatrics	9	4.3		Ultrasonic (waves)	29	14.1
	Surgery	9	4.3		Laryngoscope	9	4.3
	Otolaryngology	37	17.9		Inspirator	16	7.7
	Dental	12	5.8		Electrocardiogram machine	18	8.7
	Outpatient	4	4.3		Listening inspector	6	2.9
	Emanation	5	2.4		Microscope	9	4.3
	Homecare	15	7.2		Electromyogram	4	1.9
	Obstetrics & Gynecology	11	5.3		Phlegm machine	11	5.3
	Nursing	13	6.3		Scanner	5	2.4
	Other	20	9.8		Others	4	1.9

Measurement Model Analysis

Confirmatory factor analysis (CFA) is assessing measurement model to test convergent validity for all the variables. In arriving at the final set of items, the study deleted certain items from the initial pool of questionnaire based on the criteria of item-to-total and factor loading coefficients. The final results showed all item-to-total were above the threshold of 0.30; however, there were three items' factor loading below the threshold of 0.50. These items were deleted for further analyses.

To determine the good model fit of measurement model, the study adopted the model fit indices that recommended by Hair et al. (2006). Not only the χ^2/df must not be greater than 3.0, but also other criterions such as goodness of fit index (GFI) and adjusted goodness of fit index (AGFI) should be greater than 0.80, comparative fit index (CIF), and normed fit index (NFI) should be greater than 0.90, as well as root mean square residual (RMR), and the root mean square error of approximation (RMSEA) should not be greater than 0.05 and 0.08. The results were showed as followings: χ^2/df = 2.297; GFI= 0.856; AGFI= 0.808; CFI= 0.946; NFI = 0.908; RMSEA= 0.080; and RMR = 0.056. All indices were within the recommended value except for RMR. As the RMR was very close to the criterion, the study considered the measurement model had good fit.

Convergent analysis was assessed by computing the factor loading coefficients. Convergent validity was demonstrated by the high average variance extracted (AVE) for all constructs which greater than 0.40 were considered adequate (Verhoef and Hoekstra, 2002). Table 3 illustrated the AVE of all constructs were from the range of 0.669 (service quality) to 0.869 (perceived value) except for technology readiness (0.381) which was very close to the criterion of 0.40. Hence, the study considered all constructs had convergent validity. Besides, all Cronbach's alpha coefficient and composite reliability (CR) also had exceeded the criterion of 0.70, revealing that all constructs had high internal consistency and reliability.

Discriminant validity was assessed by computing AVE for all pairs of constructs and comparing the square root value to the correlation between two constructs of interest (Fornell and Larcker, 1981). Table 4 illustrated the results of discriminant validity analysis. It revealed all square root of the AVE (diagonal value) were larger than the correlation value between the two constructs. Therefore, the study determined that the discriminant validity was satisfied.

Table 3: Convergent Validity and Reliability Analysis.

Variable	Cronbach's Alpha	Variance Extracted	Composite Reliability
Technology-based Service Encounter	0.926	0.714	0.967
Service Quality	0.976	0.669	0.950
Perceived Value	0.951	0.869	0.994
Satisfaction	0.939	0.703	0.954
Technology Readiness	0.750	0.381	0.700

Table 4: Discriminant Validity Analysis.

Construct	TBSE	SQ	PV	SAT	TR
Technology-based Service Encounter (TBSE)	**0.845[a]**				
Service Quality (SQ)	0.602	**0.817[a]**			
Perceived Value (PV)	0.668	0.561	**0.932[a]**		
Satisfactions (SAT)	0.519	0.517	0.547	**0.838[a]**	
Technology Readiness (TR)	0.525	0.420	0.508	0.393	**0.617[a]**

Note: [a]Diagonal elements represent square root of AVE for that construct.

Path Analysis of Full model

The model parameters were the regression estimation coefficients of constructs. For accessing the model fit of full model, the same criteria were adopted as the measurement model fit indices. The path diagram and the results of full model were illustrated in Figure 2 which revealed $\chi 2 / df = 2.735$ ($p = 0.000$), GFI = 0.953, AGFI = 0.816, CFI = 0.953, NFI = 0.929, RMR = 0.069, and RMSEA = 0.092. The study determined the model had acceptable fit for further analysis.

The results of path analysis revealed the parameter estimation of TBSE towards service quality and perceived value were positive and reached statistical significance at 0.001 level ($\beta = 0.702$, $p = 0.000$; $\beta = 0.752$, $p = 0.000$). It revealed TBSE had a positive effect on service quality and perceived value; hence, the finding supported H1 and H2. Services quality and perceived value toward satisfaction also revealed positive and reached statistical significance at 0.001 level ($\beta = 0.441$, $p = 0.000$; $\beta = 0.494$, $p = 0.000$). The finding supported H3 and H4 as both service quality and perceived value positively affected satisfaction.

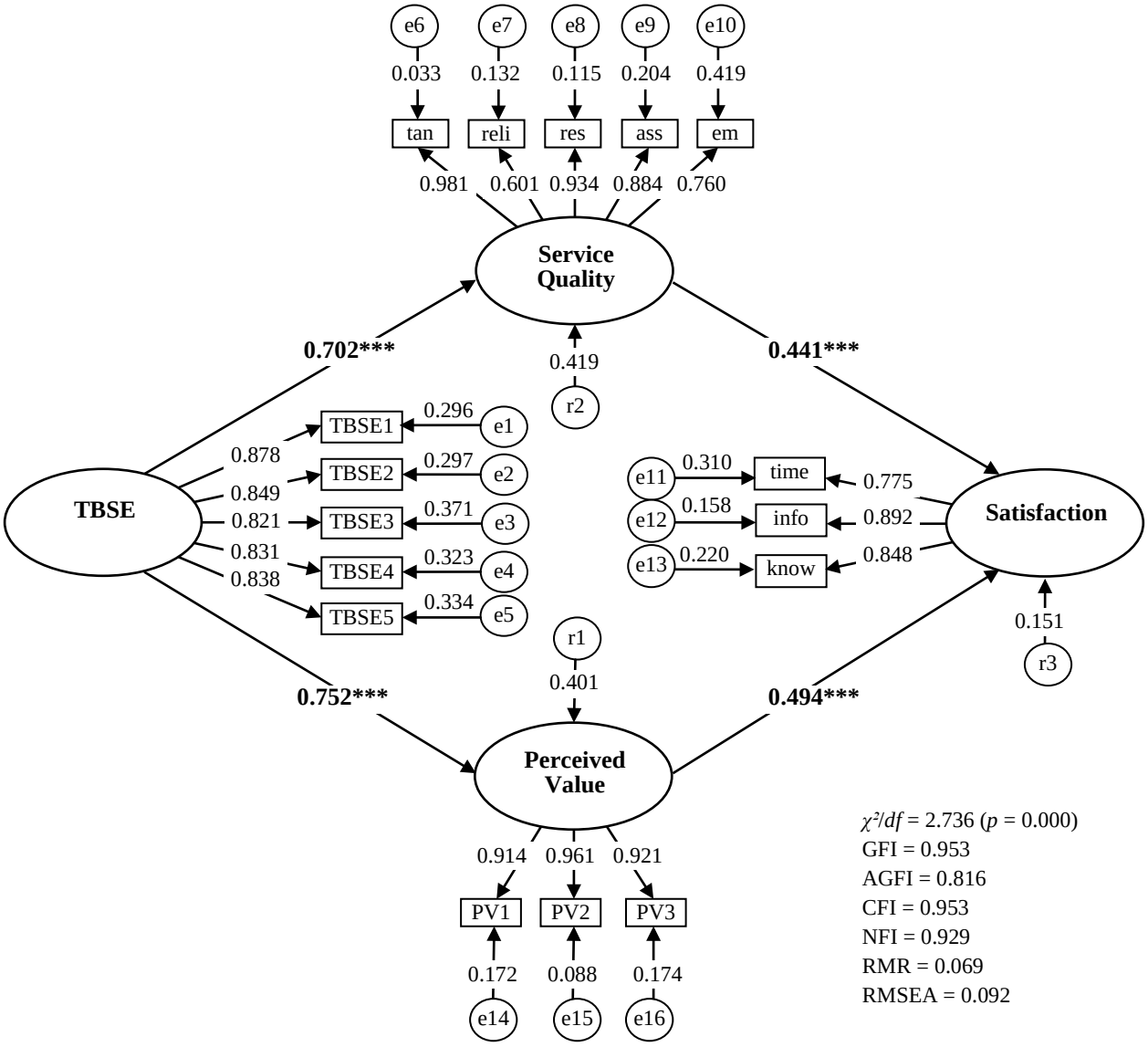

Figure 2: Path Diagram of Structural Equation Model Analysis.

Hierarchical Regression Analysis – Moderating Effect

This study adopted hierarchical regression analysis for assessing the two moderating effects of technology readiness: on the relationship between TBSE and service quality as well as perceived value. The constructs with multi-items was measured through a single index by averaging the item scores. Mean centre were computed for each constructs and interaction terms were formed. Three Models were tested for both dependent variables (service quality and perceived value) and the results of hierarchical regression analysis were illustrated in Table 5. Model 1 and Model 2 tested the direct effects of predictor variables (TBSE and technology readiness). The results revealed a significantly direct effect on both dependent variables. Model 3 tested the direct effects and the interaction term (TBSE × technology readiness). The study found that technology readiness had a positive and significant effect on service quality (β = 0.183, p < 0.01) but had not significant effect on perceived value (β = 0.103, p > 0.05). To conclude, technology readiness had a moderating effect on the

relationship between TBSE and service quality, but had not significant moderating effect on the relationship between TBSE and perceived value. Therefore, the finding supported hypothesis 5a and did not support hypothesis 5b.

Table 5: Results of Hierarchical Regression Analysis.

Dependent Variable	**Service Quality: H5a**			**Perceived Value: H5b**		
Predictor Variable	**Model 1 (*β*)**	**Model 2 (*β*)**	**Model 3 (*β*)**	**Model 1 (*β*)**	**Model 2 (*β*)**	**Model 3 (*β*)**
Direct Effects						
TBSE	0.654***	0.581***	0.483***	0.692***	0.583***	0.528***
Technology Readiness		0.164**	0.161**		0.247***	0.245***
Interaction						
TBSE x Technology Readiness			0.183**			0.103
R^2	0.427	0.449	0.473	0.479	0.528	0.536
Adjusted R^2	0.425	0.444	0.465	0.477	0.523	0.529
F-value	152.260***	82.727***	60.335***	187.613***	113.542***	77.630***
ΔR^2	0.427	0.022	0.024	0.479	0.049	0.008
ΔF	152.260***	7.978**	9.022**	187.613***	21.041***	3.269
VIF	1.000	1.243	1.243 ~ 1.650	1.000	1.243	1.243 ~ 1.650

Notes: **p<0.01; ***p<0.001

t-Test and ANOVA Analysis

A one-way ANOVA analysis was conducted for assessing the difference in all constructs across demographic variables such as age, education, position and department. *t*-Test was adopted for the assessment of gender As the results, there was no statistical difference between groups of these demographic variables for all constructs. Therefore, the study deduced that different groups of demographic variables had no differences to all constructs.

DISCUSSION AND IMPLICATIONS

Using technology-based service encounter (TBSE) as an antecedent, the objective of the study was to examine the relationships between service quality and perceived value towards satisfaction. Technology readiness was adopted as a moderator to examine its moderating effect on TBSE towards service quality and perceived value.

The results supported H1. H2, H3, and H4. Nurse is one of the most heavy loading and stressful position in the hospital. Therefore, hospital should advocate and promote a positive attitude towards launching new technological systems to reduce clinical staffs' workload and provide better treatment services quality to the patients. However, the hospital should take staffs' opinions into account when choosing a provider (brand, supplier or manufacturer) of TBSE (equipment). As the staffs use the equipment every day, they have better understanding about what functions are needed, convenient, and beneficial the most to the patients. In this line, service quality of the provider and staffs perceived value of the TBSE are also important reference for making purchase decision. When the providers are reliable and responsible to provide a tangible TBSE with assured and emphatic service, the clinical staffs would be more likely to have positive attitude towards the TBSE. Moreover, if the existing TBSE are easy, convenient, and practical to use for serving patient satisfyingly,

the staffs will definitely give their support to the management for applying TBSE widely in the future, which also can help to enhance the staffs perceived value towards the TBSE. Therefore, when the TBSE providers provide high service quality to the hospital and the clinical staffs perceive the TBSE have high value, they are more likely to have positive attitudes and satisfaction towards the TBSE.

H5a was supported but H5b was unsupported in the moderating effects test. According to Parasuraman (2000), people have strong desire for adopting new IT when they are well trained. As these people (the staffs) have higher sense of technology, they will require more or better services quality to fulfil their duties from the provider. However, the staffs will consider the TBSE has poor service quality when the providers fail to meet their needs. Some respondents comment that regardless of the staffs' high or low technology readiness, TBSE is perceived as valuable. It is because they believe IT not only can reduce paper-work, easily transfer patients' medical report from one division to another, and reduce examination steps, but also can provide complete diagnosis results to the patients. Therefore, the staffs perceived TBSE as high value. Some respondents point out that no matter they are conservative or innovative, IT is an indispensable tool in their workplace; in fact, IT bring them convenience and reduce workload.

Theoretical Implication

Prior research generally used the quality-satisfaction relationship to discuss the topic of marketing in service industry, such as Lin and Hsieh (2006), Saravanan and Pao (2007), Snellman and Vihtkari (2003), and etc. This study contributes an overall understanding on the research model is actually suitable for applying to the healthcare institute.

This study, focusing on the practitioners (e.g., the clinical staffs) who use the TBSE instead of the patients, is different from the prior research (e.g., Eriksson and Nilsson, 2007; Lin and Hsieh, 2006; Snellman and Vihtkari, 2003) which mostly emphasize on the perceptions of consumers or the people receive the services. The overall model is discussed from the viewpoint of services instead of marketing. The moderator (technology readiness) also plays a critical role in the model based upon the statistical analysis. Prior studies mostly discuss the degree of technology readiness has influence on perceived value and satisfaction of the end users (the consumers). The findings of this study imply that technology readiness not only has influence upon end users, but also the mediums (the clinical staffs) that provide services.

Managerial Implication

From the managerial perspective, the technology readiness of staffs in the healthcare institute is generally high because technological proficiencies are prerequisite for the occupation. Therefore, the staffs tend to be keen on supporting the decision of implementing new technology when it is needed (Yang and Peterson, 2004), and they could gain professional knowledge of particular technology from day-to-day experience of serving the patients. Hence, a routine meeting must be conducted to collect opinions in terms of the patients needs, and modify the working procedure to promote their effectiveness. And,

the staff opinions are also important for making decision of implementing or upgrading new technologies.

As technology changes rapidly, the management should encourage staffs to attend seminars, symposiums, conferences or exhibitions related to new technology to upgrade themselves. Different technology system certification should also be encouraged to enable cross-sectional cooperation. Accordingly, the staffs should continue their learning and exchange their knowledge to use TBSE more completely, ultimately, enhancing the service quality.

Manufacturer or provider should pay more attention to the feedback from institutes and establishing a tight relationship with them to provide better and in-time services. It not only can establish good impression to the provider, but also can enhance satisfaction of staffs' as well as patients by reducing waiting time.

Limitations and Future Research

There are several limitations to the study. Firstly, the research data are collected from institutes at different size such as private and public hospitals, or even small clinics. Secondly, it is not possible to make a comparison between different departments and different divisions in clinical institutes as the respondents are too few to divide into groups. The study believes the results may be different with other research methods.

Lastly, other constructs such as leadership style (Neufeld, Dong and Higgins, 2007) or organizational culture (Leidner and Kayworth, 2006) may play an important role in affecting staffs to use technology. These constructs are worth exploring and discussing from the organizational perspective, especially from the healthcare institute in future.

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CHALLENGES OF LAUNCHING INNOVATIVE TECHNOLOGY APPLICATIONS THROUGH CUSTOMER PROJECTS

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ABSTRACT

This study explores what kinds of launch challenges can be identified from marketing perspective when launching innovative technology applications through customer projects. The literature review identified seven launch challenge categories including, for example, launch timing decisions and sales force management. Launch challenges were further examined through a case study involving an innovative technology application developed, implemented and introduced within a customer project. In the studied empirical context the challenges differ remarkably from the literature review findings. In general, a major challenge for getting the innovative application introduced and for promoting its future sales was related to acquiring and succeeding in the first customer project, which is later utilized as a reference. That is, the launch happens through the phases of an introduction bond to the first customer project, and a possible re-launch followed by the application's further development. The study findings can be partly explained by the strategy of the examined firm and the characteristics of its business field, which are not typical in the general launch literature. This study contributes to the launch literature by extending the scope of different types of contexts where launch is researched and by discussing the implications of the context characteristics for the perceived launch challenges. The findings support the notion that launch is a context-dependent phenomenon. Therefore further studies on launch and its challenges in different types of business contexts are suggested.

Keywords: launch, challenges, innovation, technology, project business

INTRODUCTION

This study examines launch challenges in case of innovative technology applications that are developed within customer projects. Launch is the process of introducing a new product into the market for initial sale [11,59]. Its purpose is to maximize the chances of achieving the desired demand outcomes [25], and it has a significant effect on the new product's overall success [12]. Accordingly, a great deal of launch literature examines the elements of launch that contribute to new product success [9,22,25,31,33,34,38]. However, launch challenges, the other side of the coin, have been largely ignored. In addition, launch is said to be often poorly managed [33], and the launch process to be unstructured [7,24]. Therefore, it is suggested here that in order to develop a more organized approach on launch it would be important to understand the challenges of it. Because the marketing function is a focal function during launch [26,55], marketing perspective is considered suitable for examining these challenges. That means that for example production ramp-up issues are not of interest here as such, but perhaps their effects on the timing of the new product launch.

Typically launch is described as the last step of a firm's new product development (NPD) project [12]. The majority of launch research does not pinpoint the product categories and when it does, the division is made between consumer and industrial products [33]. Here the focus is on industrial product launch. New products are not always developed within internal NPD projects, but also within customer projects, after which the products are introduced for initial sale after the project. That is often the case in technology firms which match their technological capabilities with the buyers' needs, and sometimes innovative solutions are required. Hence, a launch of an innovative industrial product that has been developed within a customer project is of interest, because the project business, a customized industrial product, and launch through the first customer reference are aspects that are rarely included in launch research. This choice of context offers a possibility to further refine understanding on industrial launch.

That leads to the research question of this study: *What kinds of launch challenges can be identified from marketing perspective when launching technology applications through customer projects?* The research question is answered through a topical literature and an in-depth case study. The paper concludes with a discussion on the findings and linking them to the existing launch literature. In addition, managerial implications and ideas for further research are presented.

LITERATURE REVIEW ON LAUNCH CHALLENGES AND THE IMPLICATIONS OF THE CONTEXT CHARACTERISTICS FOR LAUNCH

Launch process includes phases such as launch planning, market testing, marketing communications planning, launch implementation and evaluation [15,44]. Launch challenges have not been systematically linked to launch process phases in the existing launch literature so the examination of launch challenges covers the whole launch process. For example pricing and distribution decisions have their own research streams, and they are not reviewed here because the focus has been on how these challenges have been discussed in the literature, where launch is the main topic of interest. Next, a review on launch challenges is presented, followed by a discussion on the characteristics of the examined launch context and their implications for launch.

The launch challenges identified in the literature

Launch timing decisions

One of the most important success factors and biggest challenges related to launch is timing [36,61]. Often the problem is delay instead of launching too early, even though that also might be an issue for example if the market is not ready for a radical innovation. Technical, engineering and development problems are often the reasons for delays [29,36], as well as deficiencies in the proficiency in executing new product development activities [10]. Delays compared to the announced launch date can have a negative effect on sales [36,9] and decrease the market value of a firm [29], even though the correlation between staying in schedule and good business results is not always existent [38]. Timing can be viewed also in relation to competitors' acts [38]. An entry too early might be risky if the technology is immature, and being too late might sacrifice the sales [36]. Timing related to firm's other

own product launches entails a question of cannibalization [42]. Cannibalization, i.e. new product harming the success of another own product of the firm, is a relevant timing problem when looking at launch at a product family level or higher [56].

Global and local launch timings are increasingly important launch issues in global markets [9,8]. An important timing question then is a choice between sequential and simultaneous launch across different markets. Simultaneous launch strategy is supported in the literature, because it is considered to lower the risks [10,37]. Sequential launches are more often delayed than simultaneous launches, which is seen to depend on the deficiencies on the sufficiency of marketing and technological resources (e.g. to train sales staff, provide after-sales service), and communication between the headquarters and local organizations [9]. Delays in sequential introductions resulted in lower-than-expected product sales and profitability [10]. Geographically dispersed virtual multicultural teams are suggested for taking care of the coordination between the headquarters and local organizations [27]. When operating in a business, where product technology customization is needed to different markets, delays are common [9]. Also the schedule of the local channel owners and customization of marketing communications might cause delays [6]. Hence, realistic schedules for marketing and R&D with sufficient resources should help to achieve a timely launch with a ready product [9].

Effects of product innovativeness on marketing

The meaning of innovativeness for launch is discussed occasionally in the NPD and the launch literature. The efficient launch process is found to be important for the success of less innovative products [54]. That implies that the launch of a more innovative product is not just about the efficiency. Innovativeness of a new product can lead to higher adoption barriers of the sales force [4,60] and the customers [1,43]. That has implications both for internal and external communications during launch. Salespeople are often more reluctant to sell innovative products than their companies expect them to be [4,60]. For sales the new product might first translate into more effort with more uncertain profits. Thus, more innovative product launches may face challenges in educating and motivating the sales force. Rackham [45] sees that the problem lies in the product-centric approach used when introducing highly innovative products to the sales force, which leads to product-centric sales approach, which eventually makes the customer interest to fade. Hence, customer-oriented communication should be utilized in launch communications, both for internal and external audiences [45].

For a buyer, innovative products are more difficult to compare with other products and the benefits might be difficult to understand, which requires learning effort and means higher perceived risk [1]. If there is no longitudinal performance data available, the perceived risk increases. For industrial firms being adventurous when buying capital goods might be costly if the risks of adopting new innovative products or technologies are realized. The buyer might not have enough resources to evaluate a complex technology and instead chooses a simpler technology [43]. Overcoming these adoption barriers successfully takes a lot of effort to educate the customer from the selling firm. Another way to affect the customer adoption barrier is to acquire the first customer reference for an innovative product, which

is essential for creating future sales opportunities [23,51]. The reference is utilized in promoting the product in order to increase seller's and the product's creditability [35].

Development of a launch strategy

Several studies point out the importance of having a well justified launch strategy with clearly defined objectives [34,31,33]. At the same time the formulation of such a strategy is perceived challenging [25]. The launch decisions most frequently made by firms are not well in line with the elements that are linked to higher new product success [33]. Unclear segmentation and positioning can lead to new product failure [52].

Sales force management

As superior skills of sales force are important for launch success, sales force management is an often discussed launch challenge [4,45]. Sales force carries out product positioning. The effect of sales force adoption of the new product on selling performance is stronger when the firm provides information on the background of the new product to salespeople through internal marketing. Marketing managers should treat sales force as a front end to customer base and put effort on presenting the new product to them in a motivating manner [4].

Promotion decisions

The own sales force and direct customers are important target groups for promotional activities, but also distribution channels should be motivated to promote and sell the new product preferably relative to competitors' products [6]. Industrial firms often use agents and brokers when introducing new products to new markets, but if the product is complex and difficult to sell, those middlemen might prefer easier to sell products, if there are no contractual or other incentives [33]. One question repeatedly presented in the launch literature is how much should be put emphasis on targeting the majority versus the innovators**,** and the conclusion is that if the effect of the innovators on the majority stays the same when the product's market penetration increases, the effort put on targeting the innovators pays off [40].

Distribution decisions

Even though integrating logistics early on in launch planning is related to launch success, the practices of doing so could be remarkably improved [15]. In addition, utilization of new distribution channels is related to unsuccessful industrial new product launches, and spending less than competitors on distribution is not the amount related to successful launches, but still industrial firms often make those decisions [33].

Launch process management

Despite of these challenges, launch is often poorly managed [33]. Taking a systematic and well-defined approach on launch process management is not a common practice [7], and unstructured launch process itself has been presented by several authors to be one notable launch challenge [7,24].

Summary of the presented launch challenges

Table 1 presents a summary of the launch challenges identified in the literature review. Launch is often examined in the launch literature through the strategic launch decisions made early in the NPD process and the tactic launch decisions which are made later in the process [32]. Launch strategy, product innovativeness, and timing can be considered to relate to strategic decisions whereas promotion, distribution, sales force management and launch process management are more tactical [32,33]. Nonetheless, the context of the studies reviewed here is typically a product-focused firm. Therefore, the applicability of the challenges identified in the existing launch literature to the context of this study is further examined through examining the scope of the reviewed literature and an empirical inquiry.

Table 1: Summary of the presented launch challenges based on the literature review.

Challenge	Explanation for the challenges and their possible consequences
Launch timing decisions	Delays related to the announced launch date caused by 1) technical, engineering and development problems, 2) customization of product or marketing communications for different markets, 3) schedules of local channel owners ▸ Negative effect on sales, decreased market value of the firm Delays related to competitors' acts ▸ Inferior position for the product, lost sales Timing not optimal related to firm's other own product launches ▸ Cannibalization Sequential launches delayed due to insufficient marketing and technological resources and deficiencies in communication between the headquarters and local organizations ▸ Lower-than-expected product sales and profitability
Effects of product innovativeness on marketing	Innovative products might raise the adoption barriers of the sales force ▸ Special requirements for internal promotion, customer-centric approach suggested Innovative products might raise the adoption barriers of the customers ▸ Special requirements for promotion to inform and to educate the customer, especially in conservative industries and when capital goods in question ▸ Important to get the first customer reference for an innovative product Product-centric approach used when introducing innovative products to the sales force ▸ Can lead customer interest to fade
Development of a launch strategy	Difficult to formulate a well justified launch strategy with clear objectives. Common combinations of launch strategy decisions not aligned with strategic decisions linked to higher new product success. ▸ Unclear positioning and segmenting can lead to new product failure
Sales force management	Motivating and informing the sales force. Assuring that the sales force carries out product positioning as intended. ▸ Unclear/unintended positioning can lead to decreased sales
Promotion decisions	All targeted customer groups, sales force and other channels should be motivated to promote and sell the new product preferably relative to competitors' products. ▸ If not successful, inferior new product sales Balancing the emphasis on targeting the majority versus the innovators ▸ If not successful, inferior new product sales
Distribution decisions	Industrial firms often use new distribution channels when entering new markets and to spend less than competitors on distribution. Logistics not integrated to launch planning. ▸ Inferior launch success
Launch process management	Unstructured launch process and poor launch management ▸ Inferior launch success

Launch of an innovative technology application by firm delivering customized integrated solutions for project customers

Launch strategy is formulated on the basis of firm strategy. As the industrial project business is the broader context of this study, the role of an application launch in such a business needs to be discussed. "*Project business is the part of business that relates directly or indirectly to projects, with a purpose to achieve objectives of a firm or several firms*." [3]. Firm strategy is aligned with performing in delivering projects, and individual applications are less central in the firm strategy, even though they are units in the offered solutions. Project refers here to the delivery of integrated solutions, which are unique combinations of products and services that address a customer's specific business problems [5]. NPD relationships for customized products require considerable buyer-seller interaction [57]. In the project business the interaction between the buyer and the seller is in a key role throughout the project and relationship marketing plays an important part in sustaining and getting customers.

Firms offering integrated solutions can move from the first bid or project of its kind in a new domain of business and aim to achieve economies of repetition [13]. Hence, a customer project can introduce an innovative technology or an application that brings new business. The first project where a particular application is implemented can be utilized as a reference, and the application can then be included in future projects [51]. The first reference is a source of learning, a technology test bench and a powerful promotional tool for reference selling and credibility, and if a reference fails, it can be decisive in the success of a new technology [23]. Literature suggests that technical verification should be conducted before the first customer project and instead the project should be utilized in forming the sales arguments [49,50]. But that is not always possible if an innovative product is developed within the project. Also firms delivering customized integrated solutions for project customers are encouraged to develop modular products and services, even though it is a complex task, in order to gain benefits of scale economies while maintaining the customer orientation [28]. Table 2 summarizes these context characteristics and their assumed implications for launch.

Table 2: Context of the study and its implications for launch.

The context elements	Implications
Project business, customized integrated solutions, importance of references	Products are less central in the firm strategy Buyer-seller interaction in an important role as well as relationship marketing Need to develop modular solutions to gain benefits of scale economies ▸ Launch through the first customer project, which is later utilized as a reference ▸ The solution is further developed after the launch

Hence, in this context launch can be considered to refer to the first project where the application is implemented, because after that the application is usually released for sales in other projects. If considering the launch definition utilized in this study, it is not a launch if the new application is communicated randomly to the customers via personal contacts but not to the broader market via some type of public announcement or introduction.

Compared to the traditional approach on new product launch, this type of launch might not be as systematic and as coordinated a process followed by intensive promotional activities.

METHODOLOGY

The in-depth, qualitative and explorative single-case study [62] concerns an industrial customer project, during which an innovative technology application was developed, implemented and introduced, and the followed promotional activities. The case is chosen in order to explore whether the challenges in the particular case context are covered by the current launch literature. The qualitative research methods are used, because it is not purposeful here to examine the subject in terms of quantity, amount intensity, or frequency [14]. Qualitative research studies phenomena in their natural setting in order to make sense of them through the meanings people bring to them [14]. Therefore, launch challenges are examined in an industrial firm through personal interviews. The 22 semi-structured interviews [2] with managers from marketing, sales, and R&D form the main data (see Table 3). The first seven interviews were conducted with the key people involved in the examined customer project. In order to link the data on the project to a broader understanding of the marketing practices of the firm, 15 interviews were conducted among marketing, communication and sales managers. The interview data is complemented by observation memos from firm workshops and meetings, where recording was not an option, and related firm documentation, which makes data triangulation possible. Data on the project, the application and its introduction, and the firm was collected also from public sources.

Table 3: The qualitative data from the case study.

Data source	Duration	References*
The seven interviews on a customer project including an innovative technology application in a chronological order:	**13,5 h**	**376**
Technology Director & VP R&D, Senior Technology Specialist, VP New Business Solutions, VP Sales I, Technology Specialist, Project Manager, VP Sales II	c.a. 2h each	
The 15 interviews on marketing practices of the firm in a chronological order:	**12 h**	**174**
VP Sales III, Corporate Communications Director, Marketing Communications Coordinator, General Manager, Sales Director, Sales & Marketing Director, VP Business Division I, Sales Manager, VP Business Division II, Communications Manager, VP Sales I, VP Sales & Marketing, Corporate Communications Coordinator, Marketing & Communications Manager, Managing Director	c.a. 1 h each	
Other materials		**144**
Meeting and observation memos, internal documents e.g. presentations and emails		94
Materials from public sources, such as press releases, annual reports, news, brochures		50

*) One coded reference includes typically ca. five to ten sentences.

The research problem is answered through systematic combining of theory and empirical data with abductive logic [16]. Analysis is based on the phases of data reduction, data display and conclusion drawing [41]. Interviews were recorded and transcribed word-to-word. QSR NVivo software was utilized for coding in order to make the data reduction more organized. Coded references from the data were first categorized based on the launch challenge categories presented in the literature review. Categories were added inductively when a challenge not covered by theory-based categories was identified. The contents of the categories were divided into sub-categories inductively in order to display the

condensed contents of the data. Several iterations of analysis were made to clarify the categories. The sub-categories from the analysis were compared to the theory-based sub-categories. Conclusions were drawn on the nature of the challenges in the examined context and to what degree the reviewed topical literature covers them.

LAUNCH CHALLENGES IN THE EXAMINED CASE

Firm introduction

As the firm strategy affects the launch strategy, a short general introduction to the examined firm is needed. The firm offers a broad range of advanced customized technology solutions with an over-the-average investment cost and lower operating costs. The targeted scale is between turn-key projects and application sales, and for the broader scale solutions the firm offers good warranties. The firm has a strong market position, reputation as a knowledgeable technology provider for challenging projects, and well known proprietary technologies and applications of which many have scantly competitive alternatives. The importance of application sales varies between business divisions offering different technologies, but in general at the time of examination the trend in the firm's marketing has been away from emphasizing individual applications. Even though customization is practically needed in every customer project, the firm has been working on to develop modular solutions. Against this brief introduction, the identified application launch challenges are discussed next.

Identified launch challenges in the examined case

Vagueness of a launch strategy

Products were perceived to have a lesser role than technologies in the firm strategy. The concept of product was not perceived unequivocal in the firm, as it can refer to different types of offerings. However, the concept of product was used by the interviewees and in the firm's marketing communications materials. The interviewees perceived that distinctive for a product is that it has a certain degree of repeating or fixed elements, even though those elements can and typically need to be customized to specific customer needs. From the marketing perspective, a product has a name and marketing materials such as brochures. Applications are often developed in customer projects whereas technologies that the applications are based on are result from the R&D.

> *"- Well, I mean a traditional product. We can't... In our firm a product, it is not...it is a piece of equipment or a process or a service or some other added value that is offered. But if we have a unique episode like in [the name of the examined project], partly unique, (...) we don't start to do brochures on the project.*
> *- No, but on this process we developed, for instance. I think that is a product.*
> *- Right. That you can do. (...) So you can think we have this case, which then brings new commercialization tasks." (Technology Director & VP R&D.)*

Thus, in the examined firm products have a less central role and a more unstable form than in firms delivering standardized products, and all this makes the concept of launch also vague, and the concept of launch strategy was barely mentioned in the interviews.

Effects of product innovativeness on marketing

According to the interviews, an innovative application is typically a result of incremental improvements realized in customer projects, which happen when designing the best possible solution for a certain customer. In some projects the existing applications are not functional and a natural need for improvements emerges. For the customer innovative applications mean potential improvements in performance, but first and foremost, risks. For the seller technological innovativeness means new business potential, but usually also compromises in project price and contract terms so that the buyer's risks are compensated. Innovative applications put special requirements for marketing communications due to their technical uncertainty, especially in conservative industries. The interviewees emphasize repeatedly that if there is no comparable reference for an innovative application, the benefits of the innovative application must be argued solely through other means, which is challenging, because references play such a central role in the marketing in this business. The functionality and performance of the application must be communicated for the customer with other illustrative manners, such as scale models, 3D models, simulations and calculations.

> *"So we showed to this fellow [a consult hired by the customer] that we have calculated it like this and take a look at that piece of equipment; the results were alike. Your thing here in you model looks very different than this physical scale model. So we agreed that let's forget about it. After that we didn't discuss it". (Technology Director.)*

When an innovative application is developed, implemented and introduced through a customer project, it means usually a challenging sales project. The first customer project where an innovative application is implemented has a high marketing communications value and the firm needs to succeed with the project in order to assure the future sales opportunities for the application. The first reference project is utilized in marketing communications of the application and it is a proof of the performance of the application, creating an image of its reliability and credibility.

> *"Well, yes, because the references mean everything in our field of business. So if you don't have a functioning reference, it will be a remarkably lot more difficult to sell the project." (VP Sales I.)*

The technical uncertainty included in an innovative application is not, however, always the only reason for customer adoption barriers. For example, the customer might have contacts to other technology providers who could potentially offer an alternative solution. Lack of trust to the seller might make the buyer to question the offered innovative solution especially when the buyer is less knowledgeable of the applied technology.

> *"I have never participated in a project with so many consults. On the other hand, they are experienced fellows, but…maybe the buyer acknowledged that they do not have enough technical know-hot to evaluate it [i.e. the solution], so they need someone. But how many and how broad commissions they made shows that they must have lacked the general*

trust towards us. The basic assumption was that we're wrong, instead of 'let's see if they are wrong'." (Technology Specialist.)

According to the interviews, if the buyer and the seller have a strong existing relationship, the innovativeness of the application might not raise customer's adoption barriers in a similar manner as when the relationship is weak or nonexistent. Trust entwined in a good relationship helps to overcome the adoption barriers and interlinked challenges along the project. Relationship marketing plays a role in how the innovative applications eventually surmount the customer's adoption barriers and assure the first reference for the application.

Promotion decisions

Promotional activities were not emphasised at the time when the innovative application was first introduced to the market, not at least in a similar manner as is typically done in a firms operating in product business. The application introduction, for example via a press release, was linked to an introduction of a particular customer project, where the application was sold and implemented for the first time. Marketing communication materials such as brochures were prepared later, such as brochures, magazine articles, white papers, and conference presentations. The contents of the marketing communication are technical, because the customers need fairly detailed information on the applications in order to know whether they are suitable for their needs. Depending on the business potential of the application, the application can be technically developed into repeatable modules and later perhaps into a product family. Then, a product family usually has several types of marketing communications materials and a new introduction might follow for the family.

"Well this piece of equipment is now developed into a product in a way, because we have produced this marketing material plus then the design is now developed into a form that we define how it will be done, measures are fixed, and how it is implemented. And I don't know if there is much else we can do about it." (Senior Technology Specialist.)

In industrial project business relationship marketing has a crucial role and other marketing activities or visibility elsewhere than at the customer has a lesser role. Relationships bring business, the realized projects and the customer network build firm credibility, and because the solutions need to be customized, in any case the personal contact to the customer and mutual trust evolved over time are important. Hence, relationship marketing and a personal contact to the customer had a dominating role in firm's marketing communications. Advertising in mass media was not practically utilized at all when considering application introductions. Printed and internet-based materials were considered appropriate along with face-to-face communications with customers during customer visits, conferences, congresses, seminars, exhibitions and fairs.

"Personal selling and personal engineering work, whatever you call it, is the key. Then probably the Internet is the next most important, then printed materials, brochures and leaflets and white papers and such. These are the most important that we need. And all these brochures and materials must be supporting the people on the field in their activities. We leave them to the customers to remember us by." (Corporate Communications Coordinator.)

Some interviewees considered this emphasis of the importance of personal contacts to undermine the role of other means of marketing communications.

"People here have this 'whatever' mentality towards communications and marketing, all units and organizations do not see it as an important activity. (...) It's not merely seen as a cost, but its potential is not seen, people don't know how to utilize it and don't understand the value it could offer to the organization." (Corporate Communications Coordinator.)

Sales force management

Sales force management was not a launch challenge in terms of sales adoption barriers. Quite the contrary, sales force sometimes sold solutions that were still under development, difficult to implement, or financially suboptimal. Therefore, it can be said that aligning the sales with the aim to offer solutions that are based on existing solutions whenever possible was not always fulfilled. Engineering personnel responsible for the detailed design perceived that if sales had consulted them, they would have been able to optimize the design. After the project is sold, customers are reluctant to accept changes. However, ad hoc developments or improvements are often done at the implementation phase, perhaps due to this issue between the sales and the engineering.

"A comment from a firm representative 'The sales has no problem as it puts the problem downwards in the chain.' The sales sells something that might not exist, and engineering tries then design what sales has promised and what customer does not want to change, because it has been already promised, even though the changes might be considered essential by the engineers." (An observation memo from a firm workshop.)

Sales force has a strong technical knowledge and the personnel are prepared to listen to the customer and to work closely with them. The sales approach is problem solving, and the personnel easily end up with unique solutions instead of offering the existing ones. The firm has a broad knowledge base, which could be utilized more efficiently.

"I think that we've rarely had a ready-made [solution]. And why should we have?" (Technology Director.)

"Actually, it [designing the solution] did not start from a scratch. Several existing units have been utilized. It is just about how to apply the existing units. (...) We have loads of expertise in this firm, but it is scattered. The challenge is how to bring it out at the right time." (Senior Technology Specialist.)

"This internal efficiency, it is linked to this development of products, so that everything would not start from a scratch, and you would have ready-made materials for calls for bids and such (…). But that is still a challenge." (VP Sales I)

Considering implications of this for launch, if the sales force does not put emphasis on promoting the existing, introduced solutions, it undermines also the effort increase the sales of the modular solutions, since no one is promoting them to the customers. Accordingly, it makes sense not to put effort on promoting new applications at the time of introduction if the life-cycle of the application remains short and new applications are developed instead.

Launch process management

The idea of launch was perceived to be vaguer than in firms that deliver standardized products. Several interviews mentioned that the concept of launch, or even product development, is complex in the firm, because the path from an idea to a commercialized product is long, and all the versions of the product along the path are unique as are the projects in which they are implemented. Launch was not perceived as a process that culminates in one event that introduces an application but the interviewees discussed a longer time-span during which the application evolves through customer projects in an unorganized manner.

> *"If you consider the normal idea-to-product, to a commercial product, this is not the same. (…) Behind a commercial product, normally, a piece of equipment or such, there are hundreds of ideas (…) based on the experience, history, re-engineering, and know-how. Those ideas have been put together, physically, so we have ended up with this product. So the number of ideas might be the same, but they come together differently, it is not this traditional…it is a different time span." (VP R&D.)*
>
> *"There are no general rules, the projects are always unique. We do not sell bread over the counter." (VP Sales I.)*

The concept of launch was, however, utilized in firm's marketing communications, but it did not refer only to the new application. For example, in press releases where they introduced the new application, launch was linked to the announcement of the related new customer project. The phenomenon of introducing something new to the market is discussed also through concepts such as introduction, bringing to market, and commercialization. All in all, the concept of launch process is rarely mentioned in the interviews and the launch process does not have a similar meaning as in product-focused firms introducing novelties to the market after internal NPD projects. As the examined firm aims to offer more modular and fixed, though customizable, applications, it is possible that application launch and new application marketing will have a different role in the future.

Pricing decisions

The price of an application was discussed in context of pricing a new, innovative technology application. An innovative application does not typically allow an excess price in the project where it is developed. The price for the project must be reasonable in order to get the project or even to get into negotiations with the customer. Usually innovativeness means compromised price due to the technological risk perceived by the customer. On the other hand, if the application is successful, the customer might gain benefits e.g. in form of improved performance. Interviewees considered that if the relationship with the customer is strong, price plays a less significant role, because the trust compensates the risk. The customer thinks that if there will be problems with the innovative application, they will be solved together.

> *"A comment from a firm representative: 'the customer might go to a competitor, if a better price is offered, even though the solution would not be as suitable and the customer might have to adapt the solution afterwards and even end up with a higher end price what we offered.' A following comment: 'Then the customer relationship has an*

important role, to make the customer stay and to prioritize other things than price'." (An observation memo from a firm workshop.)

For the seller innovative applications developed within a customer project can mean both positive and negative surprises. Sometimes the application performs better than expected, but the development and testing costs are difficult to estimate in the early phases of the project when the price is negotiated. The negotiated price is difficult to change afterwards. Therefore customers are often responsible at least part of the testing costs. The seller's price risk is compensated by the reference value of the project, if the first project including the innovative application is successful. All in all, when an innovative application is introduced, the price is more likely to be moderate than high, because the risks affect the price. When there are functioning references the price might be increased.

DISCUSSION OF THE FINDINGS

Next, the identified challenges in the examined case (see Table 4) are discussed in relation to the existing launch literature. *Launch timing* challenges were discussed in the launch literature in a number of studies, but they were not identified in the empirical data. This might be related to the firm strategy, where launch of individual applications have a lesser role. The launch is not emphasized as an individual phase on an application's long and ragged path from an idea to a salable product. Launch happens along the way, introduces the application, but a lot of can be done after the first customer project. Relationship marketing has such an established position in the field of business that it also might overrun the advantage right timing can provide. But perhaps the major explanation is that the developments in this field of business do not happen overnight. Applications include the know-how cumulated over the decades. An efficient launch process is important for the success of less innovative products [54], but in the examined context that has a lesser role, because the developments in the examined field of business are generally slow-paced. Hence, timing appears not to be as crucial in the examined context as on markets where new products are introduced continuously, relationships are less important, it is possible to acquire the knowledge the products are based on in a shorter time, and the competition is fierce.

Distribution was another launch challenge identified in the literature review, even though through a limited set of references, but not in the empirical data. The examined firm sells customized solutions directly to its limited number of customers it already knows well, and distribution channel choices are not that relevant compared to a firm that sells standardized products via multiple channels. The only challenge that was discussed in the empirical data but not in the literature review was *pricing*. Pricing issues should be carefully considered with the risks of the project when the firm wants to get the first reference customer for its innovative application. Pricing was discussed in the empirical data as another decision to make, not an especially challenging area of launch. That is, neither pricing nor distribution can be considered as major launch challenges in the examined context. The reason, why they were not presented as important launch challenges in the launch literature either, could be that distribution and pricing choices have their own research streams which have not been strongly immersed with the launch research.

Table 4: Summary of the identified challenges of an innovative technology application launch.

Challenge	Explanation for the challenge and their possible consequences
Vagueness of the concept of product and launch strategy	The concept of product somewhat ambiguous in the firm and the role of a product less central in the firm strategy ▸ The concept of launch vague ▸ Launch strategy not a central concept in the firm
Effects of product innovativeness on marketing	The first customer project has a high pressure to be a success because of its reference value. Customer adoption barrier due to the perceived risks. ▸ A challenging sales project, compromises in price and contract terms, strong warranties ▸ The benefits and functioning of the application must be illustrated to the customer ▸ A strong relationship can lower the adoption barrier as the customer trusts the seller
Promotion decisions	Promotional activities were not emphasized when introducing a new application. A typical way of introducing a new application for the first time was through a press release at the same time the related customer project was published. Relationship marketing and personal contact to the customer have a central role in marketing communications. ▸ The potential benefits of more versatile utilization of means of marketing communications are lost The content of the marketing communication is technical due to the information needs of the customers. ▸ Instead of bringing out the technical details of applications, the benefits for the customer could be emphasized
Sales force management	Coordination issues between the engineering and the sales. The sales personnel aim to solve customer problems with unique solutions. ▸ The strategy to sell more modular solutions based on existing solutions is not supported ▸ New innovative applications do not reach their sales potential after the introduction
Launch process management	The idea of a launch process is vague. Launch process is unorganized and evolves through customer projects. Launch can refer to introduction of new applications, new application generations, and new customer projects. ▸ The application is developed and launched as a part of a customer project
Pricing decisions	Innovative technology applications mean high risks and potential benefits perceived both by the customer and the seller, which are accommodated to the price. ▸ Compromised price in order to get the project and possibly the first reference

Challenges related to launch strategy, effects of product innovativeness on marketing, promotion decisions, sales force management, and launch process management were identified both in the literature review and in the empirical data, but the elaborated contents of those challenges are different.

The concept of *launch strategy* was not strongly present in the empirical data. The main reason for this appears to be the firm strategy focused on technologies, which resulted in the vagueness of the concepts of product and launch, and the launch process. This study supports the perception that firm strategy has a central role in launch strategy [31]. The firm strategy affects launch strategy, which then is the basis for launch tactics. Also the market characteristics, such as market growth and competitiveness, are relevant for launch strategy decisions [30]. Because the launch decision sets are found to be extremely sensitive to

environmental or competitive context, launch strategy research should be done in a much narrower context [32]. If the launch tactics are also strongly context dependent, it can be assumed that launch challenges are too. Perhaps the existing launch literature focuses too often to firms where the firm strategy is based on selling stand-alone non-customizable products in competitive markets. The closest studies to the launch context of this study discuss how to bring high technology or high-technology products to market [19,20,21]. In addition, service launch has also received scarcely research attention (an exception [44]).

Product innovativeness affected strongly the customer adoption barrier in the examined case but not the sales adoption barrier, even though innovative application meant challenges for sales force in convincing the customer. Promotion was strongly based on the personal contact and the importance of the reference was clear for further promoting the application after the initial introduction. The findings support the study by Dunn et al. [17] who state that personal selling is a suitable strategy for marketing high technology products whereas advertising, sales promotion, and other pull strategies are effective in marketing low technology products. The promotion strategy reminds the "lower adoption barriers" launch strategy applied by high technology companies [18].

Sales force management was linked in the literature and in the examined case to the challenges of supporting the sales strategy. The literature discussed how sales force might need motivation and education to encourage them to sell new innovative products [4], but in the examined case the challenge was reversed: how to encourage the sales of existing solutions instead of offering new, unique, not-yet-developed solutions.

Launch process was even vaguer in the examined case than discussed in the launch literature, because the role and nature of launch was different in the firm per se, not only that it would have been poorly managed. On the other hand, the path from an idea to a salable product goes through same phases of ideation, development and introduction, but they happen in a customer project or in the course of several projects, and therefore the path towards launch becomes more unpredictable. The launched product is often improved afterwards and re-launched. The lice-cycle model suggested for hi-tech products, which starts with a launch, is followed by the development of the whole product, and a re-launch [19], appears to be appropriate for the studied context. Actually, the introduction of new product features, which is a common product development activity for any firm [58], is not far from the idea of re-launch. It takes time to get the conservative customers reassured of innovations and it is not necessarily meaningful to emphasize promotional activities when an innovative application is launched for the first time. As Easingwood and Harrington [19] put it, "*It is not generally worthwhile investing hugely in the launch stage (unless you are Microsoft and are launching Windows!) because a period of time in the "chasm" is to be expected and the subsequent re-launch will provide the opportunity for a major programme of execution strategies*."

CONCLUSIONS

This study explored what kinds of launch challenges can be identified from marketing perspective when launching technology applications through customer projects. The main phases of launch are similar for launch of a product and of an innovative technology

application through a customer project, but the time scale and the launch activities differ, as well as the major challenges. With the help of the in-depth case study, the vagueness of the concept of product and launch strategy, effects of product innovativeness on marketing, promotion decisions, sales force management, and the vague launch process were identified as challenging areas of launch in the studied context.

The differences between the launch challenges identified in the literature review and in the examined case can be largely explained by the strategy of the examined firm and the characteristics of its business field, which are not included to the general launch literature examining firms offering standardized products through several distribution channels in competitive markets where relationship marketing is not in a dominating role. The firm having a firm strategy based on succeeding in technology delivery *projects* means that product has a less central role in the firm strategy, and the concept of product can be vague, and therefore the concept of launch is vague. The need for *product customization* is one reason for the vagueness of the concept of product. Products support the overall firm strategy and are developed and introduced via customer projects. Innovative applications initially introduced in customer projects are the first ever implemented versions of the application. Identified effect of *the moderate competition and importance of relationship marketing* is that advertising and other means of traditional push marketing communications are less important when initially introducing new applications. Instead, launch challenges are related to getting the first customer to buy the application that is not yet even developed. Succeeding in the first customer project is crucial due to the reference value of the first project, if the application has a high business potential. The first customer reference can be considered as the first step in a process of launching the application for a broader market. Later the perhaps a more promotional re-launch introduces a product family suited for different needs, where an application is both modular and customizable.

Theoretical implications

This study contributes to the existing launch literature; *first*, by identifying the launch challenges relevant for the particular context and illustrating in detail how they differ from the challenges identified in the existing launch literature. These challenges are only partly discussed in the existing industrial marketing or innovation literature, and only marginally in the launch literature. For example, the importance of references for launching industrial innovations [46,47,48], the meaning of the first reference for technology start-ups [49,50,51], and the challenges of choosing the first reference customer for high technology products [23] touch the launch challenges identified in this study, but they focus on references, not on launch. *Second*, the study extends the scope of different types of contexts included in launch research and discusses the effects of the context characteristics to the perceived launch challenges. With the help of the case examination it was possible to incorporate the presented context characteristics, such as customization and project business, and the challenges related to them to the launch research. In the literature review these issues were discussed through e.g. project marketing, high technology marketing, and reference marketing research. Even though launch is an established research stream, it has focused on a limited set of contexts. *Third*, the study brings empirical support for the previously mostly theoretically justified concept of re-launch [19].

Managerial implications

This study offers implications for managers responsible for new product introductions in firms operating in high technology project business. Especially the study provides an insight into the specific launch challenges they might face. The challenges are different depending on the launch context, and therefore the general wisdom of launch research might not apply to every firm. Similarly, no generic launch strategies are found [32]. All in all, the path from an idea to a modular application can be seen to go through the first customer reference, further development and a re-launch. References have such an important role in selling and marketing the innovative applications that reference management deserves special attention after the first customer project has been successfully implemented. The situation at the each reference facility should be monitored, the reference lists should be continuously updated and relationship with the reference customers nurtured [35]. Systematically thinking the application life cycle and planning marketing communication activities to the phases of launch and re-launch could help to enhance marketing communications. Even though personal contact to the customer might be the major channel for marketing communications, other means to inform the potential customers could be perhaps utilized more actively in order to support new product sales also in project business. Based on this study, Internet appears to be a good communication channel, where the information is easy to find, customers are present, and also interaction with the customers is possible, or at least the contact information is available for further inquiries.

Even though an application launch might not appear relevant for a firm focused on the delivery of customized integrated solutions, the current research encourages development of modular solutions [28], mostly in order to gain cost efficiencies and to release resources from inventing the wheel again. It is challenging to encourage innovativeness and keep the modules compatible [39], and to cut the costs and to meet the customer needs at the same time. Technologically advanced and modular applications could be considered as the core around which the customized solutions are built. So the applications are, however, important in this type of business, too.

Evaluation of the study

A single-case research design offered a possibility to build a rich description of a customer project including an innovative technology application and the marketing practices of the firm. The study offers a starting point for further studies on the topic. At the same time the limitations by exploring a single case are acknowledged. The findings of the study can be considered applicable to similar contexts, referring to application launches of firms with a strong position in relationship-based industrial project business and which compete with advanced technology. Nevertheless, the research design was built on the existing general launch literature and the theoretical generalization was conducted by linking the findings to the general launch discussion. In order to enhance the reliability of the findings the data sources and the analysis process were explained, and quotations from the interviews were presented [62]. The iterative and a stepped analysis process aimed to strengthen the internal validity of the findings so that the categorization would represent the contents of the data as literally as possible. Utilization of the case data from firm interviews and documents, researcher's memos, and public sources gave a possibility to do data

triangulation in order to support the validity of the findings [62]. No remarkable differences (i.e. how the degree of innovativeness of the introduced application was described) were identified between the data sources. It can be considered whether the concept of launch is valid in the examined firm where the concepts of product and launch were ambiguous. However, both concepts were used in the data and, even though an application launch was not in a central role compared to project marketing efforts and technology marketing, data from both the interviews and public sources contained evidence, that an application launch is an identifiable activity in the firm. Even though the concept of launch was not defined or brought up by the interviewer in the interviews so that the perceptions of the interviewees on launch would not be affected, launch referred in the empirical data to the same phenomenon as in the literature.

Avenues for future research

The findings are applicable only with caution to other contexts than specified in this study, and therefore more research is needed on the topic with broader sets of data in order to strengthen the external validity of the findings. In general, the literature on launch challenges is scattered and scarcer than the research on launch success factors. Launch challenges were not the main focus of any of the reviewed launch studies. This study does not commit on evaluating and comparing the importance of the different launch challenges, which could be another topic for future studies. The concept of re-launch was relevant in the studied context, but it fits poorly to the current launch literature which often presents launch as the last phase of a NPD process [12,24,53]. Perhaps more research effort is needed in order to understand launch and re-launch as parts of the product life cycle. This study suggests that launch could be studied in a broader set of firms than the current launch literature does, because the phenomenon of launch appears to have context-dependent characteristics. The role of product launch could be also examined in firms where the strategy is not built around products, because innovative repeatable modules, products or applications are often important parts of broader offerings, but this type of launch research is missing.

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A STUDY OF CONSUMER'S INTENTION TO RETURN THE GOVERNMENT WEBSITE ON INDUSTRIAL DEVELOPMENT BUREAU IN MINISTRY OF ECONOMIC AT TAIWAN

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ABSTRACT

At present, the Website evaluation of Government websites are starting point for general public and focus on people's convenience, data correctness, and Aesthetics, lack of customer locality and intention on return. From the Web of Industrial Development Bureau in Ministry of Economic (MOE) at Taiwan, we found that the web customers are not general people, they are special require in skill, biological, or VC. Therefore, we need a new method to evaluate the website effectiveness. Lin and Lu (2004) proposed website accepted model, this model can use to evaluate the consumer's intention of website. By using website accepted model, we adopt functional service quality, computer system quality, perceived usefulness and perceived ease of use to estimate a new model to evaluate consumer's intention to return the MOE Website in Taiwan.

The study collected 259 government web users, and got some founding as followed: 1. In functional service quality of MOE website, customer agree it they can got correct information, and full information about project related law, police of government; 2. In computer system quality, User hope that when need to use, they can connect the MOE website successfully at anytime, anywhere, and don't happen website closed or shutdown; 3. Tthe responders feel that the MOE website is usefulness and easy to use; 4. If website has all the above functions, they will like to intention on return to the government website on Industrial Development Bureau in Ministry of Economic.

Keywords: Electronic government, website user's satisfaction, intention to return, Industrial Development Bureau in Ministry of Economic.

INTRODUCTION

As technology advances and information technology advances, the portal of Internet and web site integration and promote the development of information and links. In order to reduce the distance of people, enterprises can use the Internet and websites to interact with partner companies and customers around the world. As the Internet information is completely transparent, customer loyalty lower than in the past weak, so revisit the site loyalty and willingness to greater significance. If you can maintain the loyalty of site users, the users continue to come back to the original site to use various services, it will to ensure the site's competitive advantage. Revisiting the site on behalf of customers are willing to accept a service or product means the higher degree of Internet users revisit the site and the higher degree of the Internet use.

Ministry of Economic Affairs commissioned for a variety of project are set to an entry site for people or business to check or to bid the cases. The site offered network service and retrieval service, but it lack of the function of evaluation the customer loyalty and willingness to revisit. Industrial Development Bureau Ministry of Economic Affairs, for example, offering the site of commissioned project plan is not public, but for those with special needs such as technology, biotechnology, venture capital, etc., so it is necessary to establish a new assessment models to evaluate the sites effectiveness of these sites.

LITERATURES REVIEW

E-Government

e-Government (short for electronic government, also known as e-gov, digital government, online government, or connected government) is digital interaction between a government and citizens (G2C), government and businesses/commerce/eCommerce (G2B). This digital interaction consists of governance, information and communication technology, business process re-engineering (BPR), and e-citizen at all levels of government (city, state/provence, national, and international). Essentially, the term e-Government or also known as Digital Government, refers to 'How government utilized IT, ICT and other telecommunication technologies, to enhance the efficiency and effectiveness in the public sector (Jeong, 2006).

E-Government should enable anyone visiting a city website to communicate and interact with city employees via the Internet with graphical user interfaces (GUI), instant-messaging (IM), audio/video presentations, and in any way more sophisticated than a simple email letter to the address provided at the site (Kaylor et al., 2001), the use of technology to

enhance the access to and delivery of government services to benefit citizens, business partners and employees (Deloitte Research, 2000). The focus should be on:

- The use of Information and communication technologies, and particularly the Internet, as a tool to achieve better government (OECD, 2003).
- The use of information and communication technologies in all facets of the operations of a government organization (Koh and Prybutok, 2003).
- The continuous optimization of service delivery, constituency participation and governance by transforming internal and external relationships through technology, the Internet and new media (Gartner Group, 2000).

While e-Government has traditionally been understood as being centered around the operations of government, e-Governance is understood to extend the scope by including citizen engagement and participation in governance. As such, following in line with the OECD definition of e-Government, e-Governance can be defined as the use of ICTs as a tool to achieve better governance.

E-government portals and platforms

The primary delivery models of e-Government are classified depending on who benefits. In the development of public sector or private sector portals and platforms, a system is created that benefits all constituents. Citizens needing to renew their vehicle registration have a convenient way to accomplish it while already engaged in meeting the regulatory inspection requirement. On behalf of a government partner, business provides what has traditionally, and solely, managed by government and can use this service to generate profit or attract new customers. Government agencies are relieved of the cost and complexity of having to process the transactions (Jeong, 2006).

To develop these public sector portals or platforms, governments have the choice to internally develop and manage, outsource, or sign a self-funding contract. The self-funding model creates portals that pay for themselves through convenience fees for certain e-government transactions, known as self-funding portals.

Technology Acceptance Model

David et al.(1989) originally formulated the Technology Acceptance Model (TAM) in an attempt to understand why people accept or reject information systems. Davis adapted and Ajzen and Fishbein's (1980) Theory of Reasoned Action (TRA) to intentions to accept the information technology. The original TAM explained the causal links between beliefs

(usefulness of an IS and easy of using the IS) and users' attitudes, intentions and "actual computer adoption behavior" (Davis et al. 1989). The purpose of the TMA was to explain and predict user acceptance of IS from measures taken after a brief period of interaction with the system. A person's acceptance of an IS is hypothesized to be determined by his or her intention to accept it. The intention, in turn, is determined by the person's attitude toward the IS and his/her perceptions concerning its usefulness. Attitudes are formed from beliefs a person hold about the IS (Szajna, 1996). Lin and Lu (2000) proposed website accepted model, this model can use to evaluate the consumer's intention of website. By using website accepted model, we adopt functional service quality, computer system quality, perceived usefulness and perceived ease of use to estimate a new model to evaluate consumer's intention to return the MOE Website in Taiwan.

The Portal of Project Plan Industrial Development Bureau, MOE Taiwan

The concept of electronic government was first proposed in United States in 1997, the other countries started later, but gradually mastered over the Internet to provide services to the people and interact with the public. Taiwan promoted the e-Government for more than 10 years, successful completion of the Government of network infrastructure and other medium-range plan of Internet applications. Ministry of Economic Affairs in charge of the national industrial development, to assist industrial innovation and transformation and upgrading, comprehensive counseling and assistance manufacturers in investment, strengthen the operating structure to enhance their competitiveness ability. The Industrial Development Bureau(IDB), not only to promote the various project plans, but also through the aerospace industry, rail vehicle industry, precision machinery, biotechnology and pharmaceutical industry, communications industry to helping improve the building industry, hardware and software environment, promote foreign investment, technology transfer and the introduction of industrial cooperation and capacity learn cooperation, to create a good environment for sustainable industry development.

The policy of IDB is to promote the industrial development of new and key industries, high-value industry and new services. Also to help Taiwan industrial R & D, enhance the international operations, shaping the sustainable development of a quality environment and the strengthening of industrial human resources training. The current project plan commissioned a total of 79 sites. Technology to achieve the policy objectives of the Industrial Development Bureau, commissioned the Foundation, corporation aggregate, academic research institutions, tertiary institutions and industry associations and other organizations to promote and implement the project plan to implement the policy direction of Taiwan's industrial development, a total of 4,231 counseling firms, the overall increase in firms of more than US$4.17 billion output value, the overall lower cost manufacturers up to

more than US$780 million dollars. Commissioned projects are set to have an import site plans, please refer to Figure 1.

Figure1: The Portal of Project Plan Industrial Development Bureau, Ministry of Economic Affairs.

Evaluation the Website of Government

The features of website of government can be divided into several categories: based portal, providing convenient service categories and types of information-based. RDEC of Taiwan in From year 2007, RDEC began to promote and improve government service quality, continued the year 2005 conducted executive appraisal, assessment indicators are six main items: Web site is correct, sufficient and appropriate, Site restoration, Site structure and navigation, interactive bidding function, layout and multimedia design and Website promotion and management (Development and Evaluation Commission, Taiwan, 2005).

From year 2007, RDEC began to promote and improve government service quality, continued to promote the public satisfied with the service, to ensure the public's right to know and the right to use information and to encourage agencies to provide creative integration services as the three core objectives, the creation of the Government Service Quality Award, as the evaluation of service quality to promote the people, of which government website evaluation by the Government Service Quality Award operations manual, the flow of information services dimension, including the two are assessed to provide information and retrieval services and online services and e-participation (Development and Evaluation Commission, 2008). The computer user satisfaction is the

organization provided by means of computer-based information and services, the user feeling and emotion generated by the integrated response (Pearson, 1997). Mckinney et al. (2002) research focuses on different types of user satisfaction in IS: system satisfaction, process satisfaction, and outcome satisfaction; and explores interrelationships among them. Web site information quality is whether the information provided could satisfied user demand, like the relevance of information, practical and easy to understand, accuracy, reliability, timeliness and completeness of the presentation as a judge.

Consumer intention to return the Web

Corporations spend millions of dollars a year creating and maintaining corporate websites, yet many of these sites fail to reach the organization's goals (Freemantle, 2002);. Recent research suggests that these failures reflect poor website design, yet this research lacks the specificity necessary to provide practical recommendations for improving site performance (Rosen and Purinton , 2004). Hausman and Siekpe (2009) proposed the way to fill that gap by providing specific recommendations regarding website design elements that generate positive managerial outcomes. First, he test a wide range of design elements to determine those that providing human elements and computer elements. Next, these elements are linked through intermediaries using the uses and gratifications theory, technology acceptance model, and the concept of flow to explain purchase intentions and intentions to revisit the site. Lin and LU (2004) consider the information system success model is proposed information quality, response time, system accessibility for the external technology acceptance model variables to verify the user intention to accept the use of the Internet.

RESEARCH METHODOLOGY

This study focuses on the project commissioned site of Industrial Development Bureau Ministry of Economic Affairs, to understand the site quality and site acceptance model to measure the user willing to reuse the site, the tendency, the research framework as figure 2.

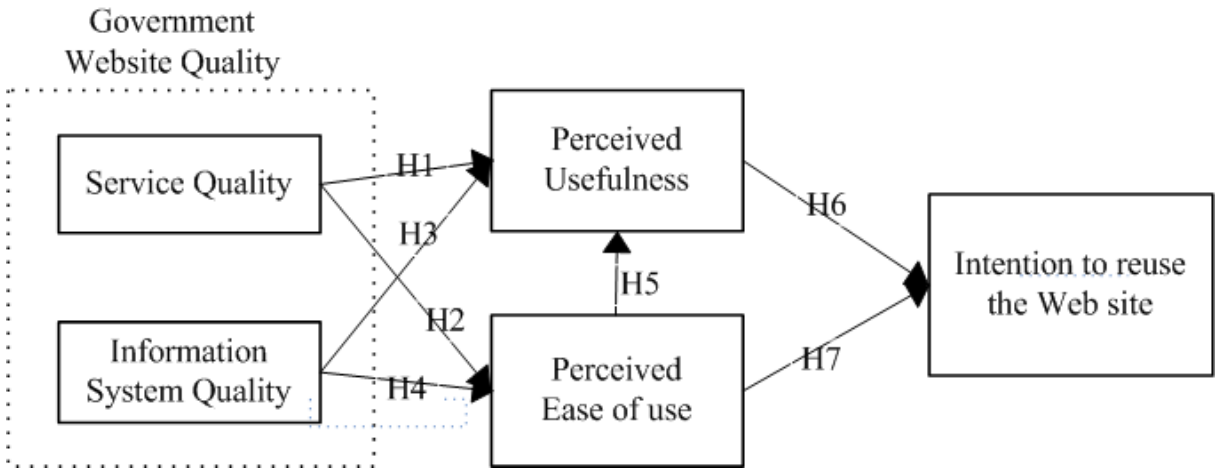

Figure 2: Framework

The Government commissioned this study to the quality of web information systems, the two parts of the affected users feel the satisfaction of Internet use, its contents and definitions are as follows; government commissioned site quality into functional service quality and the quality of the computer system, function quality of service whether to use the site to meet the needs of the user's work, including energy-related businesses on the site by public law, policy and full, accurate information, website design Category clear layout beautiful art, the site use the operating smoothly. The quality of the computer system platform for the site quality of the computer system, including Web site information to search or enter the action, the implementation of the results can be smooth and normal display, do not experience unknown site or no site is off the page to read often lead to an error occurs on this page not found. Feel part of the user: the user's knowledge and attitude on the system easy to use, or usefulness of such can be expected that the behavior of the user after use. For example, in using the Web site, whether they find easy to use, using the Internet, whether they find this site useful. The Hypothesis of this study as followed:

H1：Government Web sites Service Quality has positive correction with Perceived Usefulness
H2：Government Web sites Service Quality has positive correction with Perceived Ease of use
H3：Government Web sites Information System Quality has positive correction with Perceived Usefulness
H4：Government Web sites Information System Quality has positive correction with Perceived Ease of use
H5：Perceived Ease of use has positive correction with Perceived Usefulness
H6：Perceived Usefulness has positive correction with Intention to reuse the Web site
H7：Perceived Ease of use has positive correction with Intention to reuse the Web site

The study sample was 60 Ministry of Economic Affairs commissioned the site users, so the sample by sample surveys, site selection 5 users each commissioned to conduct a questionnaire survey sampled a total of 300 samples. And pre-test questionnaires at the 15 test the questionnaire, collect test suggested that, for some ambiguous place after the final adjustment and modification. Asked five-point Likert scale mining securities (Likert Scale), from strongly agree to strongly disagree is divided into five levels for subjects respondents. Using SPSS 12.0 Windows professional software as the statistical analysis tools. The analysis is based on descriptive statistics of the basic characteristics of the sample analysis, factor analysis to the validity analysis, and Cronbach's α for reliability analysis, regression testing with the hypothesis of this study is established.

DATA ANALYSIS

Sample Description

This study to investigate from 12/01/2010 to 12/31/2010, totally 259 valid questionnaires were collected, the analysis based on the demographic variables of gender, age, education, occupation, browser frequency. We use distribution statistics to analysis the frequent of commissioned sites, in order to understand the structure of the samples. On gender, the proportion of women slightly more, 57.14%; in the age distribution, 30 to 40 years more, accounting for 42.85%, Proportion of the age under 20 are none; to educational attainment, the university and Master degree are the largest proportion, the two combined ratio is 96.13%; in the occupation, the proportion of the general services the most, accounting for 24.71%, followed by the electronic information industry, the percentage ratio was 23.55%.

The intention of the questionnaire of users were divided into five parts, dimensions, features a total of seven parts of the service quality items, the quality of some computer systems include eight items, users feel a useful part of the total of six items , users feel easy to use part of a total of six items, intention to use the site part of a total of five dimensions of items. Respondents in the functional service quality dimensions of the answer to the results of the various items mean and standard deviation shown in Table 1, most respondents agree that the Industrial Development Bureau website to provide relevant information to the right, followed by image classification of items that the site is Clearly, the site also conforms to the image of the project design.

Table 1: Question of Service Quality.

No	Question	Mean	Standard Deviation
SQ1.	**I can get from the website of government the business plan related to public laws, policies and adequate information.**	**4.02**	**0.838**
SQ2	**It's hard to find the information provided by the website from other sites.**	**3.52**	**1.001**
SQ3.	**I think the website can provide correct information.**	**4.17**	**0.787**
SQ4.	**I think the classified projects is very clear.**	**4.05**	**0.787**
SQ5.	**The image design of the site is adequate for the project.**	**4.05**	**0.809**
SQ6.	**The layout and graphic design of the site looks good.**	**3.87**	**0.850**
SQ7.	**Operation and layout of the site is very smooth.**	**3.92**	**0.806**

Respondents in the computer system the results of quality dimensions of the answer, all items of the mean and standard deviation shown in Table 2, respondents in the quality of the most requested is smooth anywhere when needed to connect to this website, do not experience this site or unexplained construction site is off, followed by request rapidly turn smoothly site's home page in the site search or input actions, the implementation of the results can be smooth and normal display.

Table 2: Question of Information System Quality.

No	Question	Mean	S.D.
ISQ1.	**Web site links invalid, page errors or can not found won't happened.**	**4.01**	**0.934**
ISQ2.	**When I need a smooth connection anytime, and anywhere when browsing this site, the web site is under construction or unexplained close will not happened.**	**4.13**	**0.920**
ISQ3.	**When I entered this site or the information search actions, the implementation of the results can be smooth and normal.**	**4.03**	**0.882**
ISQ4.	**I think the home page opens quickly and smoothly.**	**4.05**	**0.857**
ISQ5.	**I think the site's pages reads fast.**	**3.97**	**0.877**
ISQ6.	**I think the website information text and picture is easy to understand.**	**3.97**	**0.866**
ISQ7.	**Site have a privacy policy or information security policy statement**	**3.86**	**0.937**
ISQ8.	**Personal data privacy protection can be trusted.**	**3.95**	**0.913**

Respondents feel useful to the user to answer the result dimension, the items of the mean and standard deviation shown in Table 3, respondents felt the site useful, feel that this site as a whole, the website of the respondents Very useful and practical help.

Table 3: Question of Perceived Ease of use.

No	Question	Mean	S. D.
PEU1.	**Learn to use this web site is very easy.**	**4.11**	**0.808**
PEU2.	**When Using this site will not be confused.**	**4.03**	**0.837**
PEU3.	**Using this site will not have unexpected error messages.**	**4.05**	**0.886**
PEU4.	**Get the information from this site is easy.**	**4.09**	**0.808**
PEU5.	**It is easy to familiar with the website.**	**4.15**	**0.827**
PEU6.	**Overall, I think this site is easy to use.**	**4.16**	**0.813**

Respondents felt use dimensions in the user answers, the results of the various items mean and standard deviation as shown in Table 4, respondents felt the site easy to use, think of this site as a whole, the website by respondents very easy to use and easy to learn, easy to proficiency.

Table 4: Question of Perceived Usefulness.

No	Question	Mean	S.D.
PU1.	**Without this site, will make me feel bad.**	**3.79**	**0.904**
PU2.	**This site is actually helpful to me.**	**4.03**	**0.828**
PU3	**Use of this site will improve my efficiency.**	**3.92**	**0.802**
PU4	**Use of this Web site can save lots of time for me.**	**3.95**	**0.856**
PU5.	**This website enhance the quality of deal with things.**	**3.88**	**0.866**
PU6.	**Overall, I think this site is useful to me.**	**4.04**	**0.835**

Intention of the respondents in the use of the website to answer the result dimension, all items of the mean and standard deviation shown in Table 5, respondents intention in the use of websites, find this site were satisfied and considerable like to use this site..

Table 5: Question of Intention to reuse the Web site.

No	Question	Mean	S.D.
ITR1.	**Overall, I like to use this site a lot.**	**4.00**	**0.849**
ITR2.	**I think it is a very good choice to use the site.**	**4.04**	**0.794**
ITR3.	**I am satisfied with this site.**	**4.04**	**0.806**
ITR4.	**If use such government websites in the future, I will think of this web site.**	**4.12**	**0.843**
ITR5.	**If need use such government web sites, I will definitely use this site.**	**4.11**	**0.859**

Reliability and Validity

In this study, using factor analysis to reduce or inductive dimension variables, using principal component analysis (Principal Components Analysis) for each dimension of scale, structure factors were extracted, and the orthogonal axis method (Orthogonal Rotation) of the maximum variation Method (Varimax) for the shaft to obtain the rotation matrix load, while using Cronbach's α coefficient to detect the dimensions of the questionnaire reliability.
Functional service quality dimensions are 7 questions asked were designed items, the principal component analysis to factor analysis, variance explained 59.230%, KMO value is 0.859, P-value is 0.000, see Table 6.

Table 6: Factors analysis for Service Quality.

	Content of factors	Factor loadings Component 1
SQ4.	**I think the classified projects is very clear.**	**0.860**
SQ5.	**The image design of the site is adequate for the project.**	**0.836**
SQ7.	**Operation and layout of the site is very smooth.**	**0.836**
SQ3.	**I think the website can provide correct information.**	**0.780**
SQ6.	**The layout and graphic design of the site looks good.**	**0.778**
SQ1.	**I can get from the website of government the business plan related to public laws, policies and adequate information.**	**0.726**
SQ2.	**It's hard to find the information provided by the website from other sites.**	**0.517**
Extraction Sums of Squared Loadings Total		**4.146**
Extraction Sums of Squared Loadings % of Variance		**59.230**
Extraction Sums of Squared Loadings Cumulative%		**59.230**
KMO= 0.859	**Bartlett's Test of Sphericity = 966.230**	**Sig=0.000**

System Quality dimension have 8 questions to asked, the principal component analysis factor analysis, the dimensions extracted from a factor, the overall cumulative explained variance was 62.510%, KMO value of 0.870, P-value of 0.000, see Table 7.

Table 7: The Factors analysis for Information System Quality.

	Content of factors	Factor loadings Component 1
ISQ6.	I think the website information text and picture is easy to understand.	0.851
ISQ5.	I think the site's pages reads fast.	0.841
ISQ3.	When I entered this site or the information search actions, the implementation of the results can be smooth and normal.	0.835
ISQ4.	I think the home page opens quickly and smoothly.	0.818
ISQ2.	When I need a smooth connection anytime, and anywhere when browsing this site, the web site is under construction or unexplained close will not happened.	0.814
ISQ1.	Web site links invalid, page errors or can not found won't happened.	0.755
ISQ8.	Personal data privacy protection can be trusted.	0.734
ISQ7.	Site have a privacy policy or information security policy statement	0.657
Extraction Sums of Squared Loadings Total		5.001
Extraction Sums of Squared Loadings % of Variance		62.510
Extraction Sums of Squared Loadings Cumulative%		62.510
KMO= 0.870	Bartlett's Test of Sphericity = 1438.896	Sig= 0.000

Dimensions of the user feel easy has 6 questions to asked, the principal component analysis to factor analysis, variance explained 79.097%, KMO value is 0.898, P-value is 0.000, see Table 8.

Table 8: The Factors analysis for Perceived Ease of use.

	Content of factors	Factor loadings Component 1
PEU6.	Overall, I think this site is easy to use.	0.918
PEU5.	It is easy to familiar with the website.	0.903
PEU2.	When Using this site will not be confused.	0.901
PEU1.	Learn to use this web site is very easy.	0.879
PEU4.	Get the information from this site is easy.	0.872
PEU3.	Using this site will not have unexpected error messages.	0.861
Extraction Sums of Squared Loadings Total		4.746
Extraction Sums of Squared Loadings % of Variance		79.097
Extraction Sums of Squared Loadings Cumulative%		79.097
KMO= 0.898	Bartlett's Test of Sphericity = 1453.309	Sig= 0.000

Dimensions in the user feeling useful questions to ask a total of 6 items designed by the principal component analysis to factor analysis, variance explained 78.254%, KMO value is 0.917, P-value is 0.000, see Table 9.

Table 9: The Factors analysis for perceived usefulness.

Content of Factors		Factor loadings Component 1
PU6.	**Overall, I think this site is useful to me.**	**0.922**
PU3.	**Use of this site will improve my efficiency.**	**0.906**
PU4.	**Use of this Web site can save lots of time for me.**	**0.888**
PU2.	**This site is actually helpful to me.**	**0.883**
PU5.	**This website enhance the quality of deal with things.**	**0.882**
PU1.	**Without this site, will make me feel bad.**	**0.825**
Extraction Sums of Squared Loadings Total		**4.695**
Extraction Sums of Squared Loadings % of Variance		**78.254**
Extraction Sums of Squared Loadings Cumulative%		**78.254**
KMO= 0.917	**Bartlett's Test of Sphericity = 1402.229**	**Sig= 0.000**

Intention of using the site dimensions are 5 questions asked were designed items, the principal component analysis to factor analysis, variance explained 80.843%, KMO value is 0.852, P-value is 0.000, see Table 10.

Table 10: The Factors analysis for Intention to reuse the Web site.

Content of Factors		Factor loadings Component 1
ITR2.	**I think it is a very good choice to use the site.**	**0.907**
ITR1.	**Overall, I like to use this site a lot.**	**0.904**
ITR3.	**I am satisfied with this site.**	**0.903**
ITR4.	**If use such government websites in the future, I will think of this web site.**	**0.900**
ITR5.	**If need use such government web sites, I will definitely use this site.**	**0.882**
Extraction Sums of Squared Loadings Total		**4.042**
Extraction Sums of Squared Loadings % of Variance		**80.843**
Extraction Sums of Squared Loadings Cumulative%		**80.843**
KMO= 0.852	**Bartlett's Test of Sphericity = 1246.530**	**Sig= 0.000**

This study adapt Cronbach's α to test the reliability of each variable, the results shown in Table 11, the study of factors extracted dimensions Cronbach `s α values were more than 0.6 more than the standard, this study measured the dimensions of the results are an effective degree and reliability.

Table 11: Constructs and Validity.

Construct	No of question	Total	Cronbach`s α
Service Quality	**SQ4、SQ5、SQ7、SQ3、SQ6、SQ1、SQ2**	**7**	**0.874**
Information Systeim Quality	**ISQ6、ISQ5、ISQ3、ISQ4、ISQ2 ISQ1、ISQ8、ISQ7**	**8**	**0.912**
Perceived Ease of use	**PEU6、PEU5、PEU2、PEU1、PEU4、PEU3**	**6**	**0.947**
Perceived Usefulness	**PU6.、PU3、PU4、PU2、PU5、PU1**	**6**	**0.943**
Intention to reuse the Web site	**ITR2、ITR1、ITR3、ITR4、ITR5**	**5**	**0.940**

Hypothesis test and discussion

The Government commissioned site features a useful sense of service quality for users (H1) and the users feel easy to use (H2) of the hypothesis of the regression analysis are shown in Table 12 and Table 13 shows, the hypotheses H1 and H2's not been significant. The results support that the Government commissioned website features a useful sense of service quality for users feel easy to use and user does not exist significant positive correlation.

Table 12: The Regression Model of Government Web sites Service Quality to Perceived Usefulness.

Regression	**Dependent：Perceived Usefulness**			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Service Quality	**0.9799**	**-0.208**	**-3.415**	**0.01**
Test Value	**R Square = 0.043**		**Adjusted R Square = 0.040**	
	F= 11.664		**P= 0.01**	
	Durbin-Watson= 1.574			

Table 13: The Regression Model of Government Web sites Service Quality to Perceived Ease of use.

Regression	Dependent：Perceived Ease of use			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Service Quality	**0.9887**	**-0.162**	**-2.629**	**0.09**
Test Value	**R Square = 0.026** **F= 6.911** **Durbin-Watson= 1.474**		**Adjusted R Square = 0.022** **P= 0.09**	

Hypothesis H3, the results of regression analysis in Table 14, shows the results of this study support the hypothesis H3, that the Government commissioned site computer system useful for the quality of the user has a positive correlation between sensation. Hypothesis H4 regression analysis in Table 15, shows the results of this study support the hypothesis H4, that the Government commissioned the quality of the user computer system site easy to use has a positive correlation between sensation.

Table 14: The Regression Model of Government Web sites Information System Quality to Perceived Usefulness.

Regression	Dependent：Perceived Usefulness			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Information Systeim Quality	**0.6961**	**0.719**	**16.595**	**0.000****
Test Value	**R Square = 0.666** **F= 275.400** **Durbin-Watson= 1.807**		**Adjusted R Square = 0.515** **P= 0.000**	

Table 15: The Regression Model of Government Web sites Information System Quality to Perceived Ease of use.

Regression	**Dependent：Perceived Ease of use**			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Information Systeim Quality	**0.5787**	**0.816**	**22.653**	**0.000****
Test value	**R Square = 0.666** **F= 513.164** **Durbin-Watson= 1.720**		**Adjusted R Square = 0.665** **P= 0.000**	

Hypothesis 5 of the regression analysis are shown in Table 16, shows the results of this study support the hypothesis H5, that users feel the useful and ease to use has a positive correlation.

Table 16: The Regression Model of Perceived Ease of use to Perceived Usefulness.

Regression	**Dependent：Perceived Usefulness**			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Perceived Ease of use	**0.7088**	**0.707**	**16.017**	**0.000****
Test value	**R Square = 0.500** **F= 256.532** **Durbin-Watson= 1.890**		**Adjusted R Square = 0.498** **P= 0.000**	

Hypothesis H6 regression analysis in Table 17 shows the results of this study support the hypothesis H6, that users feel useful to use the site has a positive correlation between the intention.

Table 17: The Regression model of perceived usefulness to intention to reuse the Web site.

Regression	**Dependent：Intention to reuse the Web site**			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Perceived Usefulness	**0.5917**	**0.807**	**21.906**	**0.000****
Test value	**R Square = 0.651** **F= 479.869** **Durbin-Watson= 1.806**		**Adjusted R Square = 0.650** **P= 0.000**	

Hypothesis H7 regression analysis in Table 18 shows the results of this study support the hypothesis H7, the user feels that the intent-to-use Web site with the use of positive correlation.

Table 18: The Regression model of perceived ease of use to intention to reuse the Web site.

Regression	**Dependent：Intention to reuse the Web site**			
Independent	**Std. Error of the Estimate**	**Standardized Coefficients Beta**	**t**	**Sig.**
Perceived Ease of use	**0.6385**	**0.771**	**19.383**	**0.000****
Test value	**R Square = 0.594**		**Adjusted R Square = 0.592**	
	F= 375.697		**P= 0.000**	
	Durbin-Watson= 1.641			

Hypotheses proposed in this study's findings, as shown in Table 19, pursuant to our proposed use of the technology acceptance model users of the site of the Government commissioned the intention of influencing factors on the quality of access to a computer system can indeed Using the technology acceptance model, will affect the user's site uses intention.

Table 19: The results of hypothesis testing.

	Hypothesis	**Result**
H1	**Government Web sites Service Quality has positive relation with Perceived Usefulness**	**Not supported**
H2	**Government Web sites Service Quality has positive relation with Perceived Ease of use**	**Not supported**
H3	**Government Web sites Information System Quality has positive relation with Perceived Usefulness**	**Support**
H4	**Government Web sites Information System Quality has positive relation with Perceived Ease of use**	**Support**
H5	**Perceived Ease of use has positive relation with Perceived Usefulness**	**Support**
H6	**Perceived Usefulness has positive relation with Intention to reuse the Web site**	**Support**
H7	**Perceived Ease of use has positive relation with Intention to reuse the Web site**	**Support**

CONCLUSION

This study was to explore the effectiveness of the Website of the Government commissioned project. After Web survey, we got several important results: (1) functional service quality level, respondents believed that they can get correct information from the

website, to get Ministry of Economic Affairs commissioned the business plan related to public laws, policies and full information. (2) The computer system quality, Users hope that when need to use, they can connect the MOE website successfully at anytime, anywhere, and don't happen website closed or shutdown; (3) The responders feel that the MOE website is usefulness and easy to use; (4) If website has all the above functions, they will like to intention on return to the government website on Industrial Development Bureau in Ministry of Economic, they will like to use this site definitely.

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MANUFACTURING CAPABILITIES PRIORITIZATION TO ACHIEVE CUSTOMER FOCUS IN KNOWLEDGE-INTENSIVE ENVIRONMENTS

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ABSTRACT

This paper explores the significance of knowledge attributes to establish a competitive manufacturing capability by further developing an understanding of knowledge and manufacturing strategies in small and large companies. A theoretical framework is developed initially. Later on an intensive survey of small and large manufacturing companies leads to the design of a process to prioritize manufacturing capabilities. Results show that large manufacturing companies putting higher demand for know-why knowledge attribute by considering all manufacturing capabilities to achieve customer focus. On the other hand, small size manufacturing companies putting higher demand for know-what knowledge attribute just by considering two manufacturing capabilities like quality and delivery. Results are derived from a limited number of empirical data only in one country, therefore these cannot be generalized. Future research with larger samples of small and large manufacturing firms from other countries is needed. To be competitive, manufacturing companies must reshuffle their production strategies to allow the company to play a part in global knowledge-intensive competition. Therefore, they should incorporate knowledge attributes as a way to achieve higher levels of firm performance. This study is among the first and most exhaustive studies carried out in the small and large size firms operating in the manufacturing sector. It provides a conceptual model of how four manufacturing capabilities are being exploited to achieve customer focus by being specific in three knowledge attributes like: know-what, who-how and know-why.

Keywords: Knowledge management, knowledge intensive environments, manufacturing capabilities, manufacturing companies, production, and customer focus

INTRODUCTION

In recent years, there has been an escalating concentration on the knowledge-based organization (Robertson and Swan, 2004) since the world shifts from an industrial age to an information-based era (Teo et al., 2008). In order to survive and remain competitive, small and large manufacturing firms, require creating and restoring knowledge continuously (Valkokari and Helander, 2007). Knowledge has become an essential source of value generation and sustainable competitive advantage (Teece, 2005; Ajmal et al., 2009). The ability of manufacturing firms to create knowledge persistently and manage it strategically is viewed as critical to organizational success and survival (Nonaka and Teece, 2001; Desouza and Awazu, 2006).

Organizations that build up and leverage knowledge resources attain greater success than firms who are more reliant on tangible resources (Autio et al., 2000). Knowledge

management is ever more becoming an primary business function for many firms as well as for individual projects (Ajmal et al., 2010), as they realize that organizational competitiveness pivot on the effective management and creation of knowledge (Randeree, 2006).

On the other hand, competition in the manufacturing sector has increased as globalization and customer requirements have evolved. Manufacturing companies are increasingly influenced by intense foreign competition, rapid technological change, shorter product life-cycles and customers ever more unwilling to settle for mass-produced items or services with limited value (Krause et al., 1998; Hitt et al., 1998; Zhang et al., 2003). Customers are having full fledged knowledge demand greater responsiveness to a dynamic set of requirements. Now, organizations are competing not only with their external capabilities but also on their abilities to leverage manufacturing capabilities.

Increased customer requirements coupled with competitive pressure from globalization have forced managers to ensure that their organization's resources are well aligned not only across all functional areas but also throughout the entire supply chain. This alignment is the key in developing and maintaining manufacturing capabilities required in meeting evolving customer demands in knowledge-intensive environments.

The primary goal of this paper is to assess the significance of knowledge attributes for achieving customer focus goal by taking into account the manufacturing capabilities in small and large manufacturing companies. The paper is structured as follow. First it portraits theoretical background of the concepts used in the study. Second it describes research methodology and preliminary findings. Finally, it comes with the conclusions and future research directions.

LITERATURE REVIEW

Manufacturing capabilities

The major theme of manufacturing capabilities is the manufacturers' choice of emphasis among key tasks. These capabilities or competitive priorities include cost efficiency, high quality, fast and reliable delivery, and product/process flexibility (Hayes and Wheelwright, 1984; Hill, 1994; Krajewski and Ritzman, 1996). Recent studies suggested that manufacturing capabilities are built sequentially over time. First, a solid foundation of quality; second, delivery; followed by low cost and flexibility capabilities. Four competitive priorities, the dimensions on which a firm's operations have elected to compete in the marketplace (Hayes and Wheelwright, 1984), have been generally accepted in the literature. They are (i) cost (ii) quality (iii) flexibility; and (iv) delivery.

Cost

Competing in the marketplace on the basis of cost efficiency requires striving for low cost production. In order to keep manufacturing costs competitive, managers must address materials, labor, overhead, and other costs. Inventories have long been the focus of cost reduction in factories and are one of the justifications of the JIT system. Therefore, inventory and inventory-related items, such as improving vendor's quality, reducing waste of purchased materials, are considered as the indicators of the cost capability. Realizing low inventory level, decreasing labor cost, and reducing machine time are all positive factors of the cost efficiency construct.

Quality

Quality has been identified as a manufacturer's capability to compete in the world market (Hill, 1994; Krajewski and Ritzman, 1996). Quality was defined as process quality and pre-sale, transactional, and post-sale services. Quality means superior features and close tolerance of the product. The strength of the quality control/assurance function in the plant is the indicator of quality emphasis (Evans and Lindsay, 1996). Quality also means helpfulness, courteousness, availability of service employees, and convenience of access to service. Pre-sale service enables manufacturers to get information about their customers' needs and provide what the customers want. Transactional service includes good description, documentation, and training. Post-sale service includes installation, warranty, alterations, and repair.

Flexibility

Flexibility is the ability to respond to changes. In this study, the construct was defined primarily in terms of increasing and/or decreasing of product mix, volume, and product design. Flexibility is the ability to accommodate the unique needs of each customer and typically implies that the production operating system must be flexible to handle specific customer needs and changes in design. Product mix flexibility is measured by the frequency of occurrence of product mix changes. Volume flexibility is, on the other hand, to accelerate or decelerate the rate of production quickly to handle large fluctuations in demand.

Manufacturing flexibility was originally defined as the ability of a manufacturing firm to respond to environmental changes (Mandelbaum, 1978; Li, 2000). Research by Upton (1995) defined manufacturing flexibility as the capability to react to market changes within a shorter time and at less cost. Other researchers have suggested that manufacturing flexibility is a multi-dimensional construct that could be measured in many different ways (Sethi and Sethi, 1990; Gerwin, 1993; Duclos et al., 2003; Dreyer and Gronhaug, 2004). Recent studies have categorized manufacturing flexibility into internal and external flexibility (Upton, 1995; Chang et al., 2003). The internal manufacturing flexibility is relative to the need to meet customer requirements efficiently and not directly related to market demand and environmental uncertainties. Examples of internal manufacturing flexibility are machine, component, material, and routing flexibilities.

Conversely, external manufacturing flexibility is relative to the need of customer requirements. It is usually recognized well by customers since it directly affects a firm's competitiveness. Examples of external manufacturing flexibility include new product flexibility, product mix flexibility, and volume flexibility. Sethi and Sethi (1990) and Gerwin (1993) defined new product flexibility as the ability to develop new product models quickly and product mix flexibility as the ability to provide product variety in the market. Volume flexibility permits the manufacturers to increase or decrease in the aggregate production level without incurred transition penalties. In regards to delivery, we could talk about speed of delivery or delivery dependability. It is clear that delivery reliability deals with the ability to meet quoted (make-to-order environment) and/or anticipated (make-to-stock environment) dates and quantities. In terms of quality, we could talk about quality of conformance specifications or quality of features of products, and so on.

Swamidass (1988) distinguishes machine-level flexibility from plant-level flexibility. The former being "predominantly technology based" and the latter being derived from a combination of technology, infrastructure, design and engineering capabilities, and the competitive goals and objectives of a firm. Upton (1994) defines internal flexibility as the operations strategy and the set of capabilities a firm nurtures to respond to its environment, and external flexibility as capabilities possessed by the firm and used to accommodate sources of variability to which the firm must respond and which are seen as flexible by the market. This external dimension fits the two major strategies proposed by Hyun and Ahn (1992) for using flexibility: reactive and proactive. In the same vein, Gerwin (1993) also suggests two major strategies for using flexibility: adaptive and redefinition. The adaptive strategy refers to the defensive or reactive use of flexible competencies to accommodate unknown uncertainty, while the redefinition strategy refers to the proactive use of flexible competencies to raise customer expectations, increase uncertainty for rivals and gain competitive edge.

Delivery

Delivery capability is a time issue. Delivery is usually defined in a number of aspects of an organization's operations. One is how quickly a product or service is delivered to a customer. Another is how reliably the products or services are developed and brought to the market. The third is the rate at which improvements in products and process are made (Krajewski and Ritzman, 1996). Many companies seek to maintain or increase their customer base by focusing on the competitive priorities of development speed, and fast and reliable delivery. With time-based competition managers need to carefully identify the steps and time needed to deliver a product or service and then analyze the trade-off between time and cost, and between time and quality.

Customer focus

Customer focus can be defined as the degree to which an organization always fulfils customer requirements and expectations (Philips Quality, 1995). A winning organization must be proverbial with the need to consign the customer as the first priority in every decision taken (Zhang, 2000). The key purpose of an organization is to keep up an invariable association with the customer. Such as, counting customers' proposals in knowledge creation activities, storing knowledge that is valuable to customers, reviewing

customer complaints and applying that knowledge to fulfill customer needs and enhance customer satisfaction (Ju et al., 2006). Bassi and Van Buren (1999) emphasize that the intellectual assets of an organization are not just employees' know-how, but also business process and customers' knowledge as well. Liao (2006) explicates that sharing the information and knowledge about customer needs among co-workers or leaders could proceed as a competitive advantage to the business. Fast learning and knowledge transfer from an individual to another is what an organization must do extremely well in order to retain the products and services in front of the needs and anticipation of customers (Pfister, 2002).

Stankosky (2001) signifies that organizations must comprehend that their customer's problems and needs are absolute and that they are the major inputs of incessant progress and novelty. The customer-focused knowledge strategy focuses on incarcerating knowledge about customers, understanding of customers' needs and bringing the knowledge of the organization to put up with customer problems (O'Dell et al., 1999). Thus, we compose the following section to elaborate the significance of knowledge for manufacturing organizations.

Knowledge and manufacturing

Knowledge is vibrant, relational and based on human action (Davenport and Prusak, 1998; Nonaka and Takeuchi, 1995). There are two kinds of knowledge, explicit and tacit (Polanyi, 1967; Nonaka and Takeuchi, 1995). Explicit knowledge refers to codified knowledge, which is effortlessly transmitted in a formal, explicit and systematic language. Tacit knowledge refers to knowledge that remains much harder to transfer, formalize or codify, due to its individual superiority. Tacit knowledge as divergent to explicit is profoundly rooted in action, commitment and involvement in a specific situation or context (Tsoukas and Vladimirou, 2001) and involves cognitive and procedural components.

The next generation of manufacturing businesses must be in a position to make use of information and extract knowledge from information system and the competitive environment to maximize their return (Davenport and Prusak, 1998) and reuse knowledge for innovation (Hung et al., 2005). This approach converts data to information and transforms information to knowledge (Ajmal and Koskinen, 2008) so that business intelligence can be devised and used in the decision-making process. Nonaka (1994) distinguished knowledge into explicit and tacit. Explicit knowledge is precisely and formally articulated and codified in documents and databases of corporate procedures and best practices (Alter, 2002). Tacit knowledge is the practical wisdom possessed by experts that is difficult to capture, yet repeatedly demonstrated in contexts as varied as factory floors, research laboratories, army basis, and corporate board rooms (Crowley, 2000). Knowledge management has been applied in manufacturing (Paiva et al., 2002; Wang et al., 2004), new product development (Ding and Peters, 2000), production management (Wagner et al., 2000), continuous improvement system (Beckett et al., 2000), customer relationships management (Xu and Walton, 2005), supply chain management (Fan et al., 2000); and online procurement (Hsieh et al., 2002).

However, little research can be found on the application of knowledge management dimensions for prioritization of manufacturing capabilities in highly knowledge-intensive environments. Acquiring knowledge is often associated to learning (Argote, 1999). In manufacturing, there are in-process learning and off-line learning (Upton and Kim, 1998). Lapre and Wassenhove (2002) distinguished these methods as operational learning (yields know-how) and conceptual learning (yields know-why). Following table 1 has elaborated know-what, know-how, and know-why concepts which can be also called as knowledge dimensions (Ajmal et al., 2009a).

Table 1: Knowledge Attributes.

Knowledge Attributes	Features	Practical Examples
'know-what' It specifies what action to take when presented with a set of stimuli. For instance, a salesperson who has been trained to know which product is best suited for various situations.	Least sophisticated variety Easy to apply Incorporated in many computer-systems	In the insurance and banking industries customer service representatives who use database systems to address customer questions about products ranging from dishwashers to latest digital TV sets.
'**know-how'** It is, knowing how to decide on an appropriate response based on a diagnostic process, whether in sales, medicine or any other area. It permits a professional to determine which treatment or action is best.	Sophisticated variety Not easy to apply	In the above mentioned example when customer service representatives suggest the appropriate available option that is most suitable/appropriate for the customers according to their requirements.
'**know-why'** It involves an understanding of underlying theory and/or a range of experience that includes many instances of interactions and exceptions to the norms and conventional wisdom of a profession.	Most Sophisticated variety Complicate to apply	Knowing that an unusually high level of sales might be due to an interactive effect – an influence of one factor that only operates at certain levels of another factor would also represent such 'know-why' knowledge.

Knowledge is debatably the most vital resource of organizations (Grant, 1996). More specifically, know-what corresponds to an understanding of the specific system configurations that different customer groups may want and the different uses they may put these systems to (Garud, 1997). Consequently, learning takes place through interactions between suppliers and customers (Garud, 1997; Von Hippel and Tyre, 1993)

and requires the incorporation of knowledge from different knowledge domains (Newell et al., 2005; Okhuysen and Eisenhardt, 2002).

Know-how symbolizes an understanding of procedures required to manufacture each component and an understanding of how components should be put together to perform as a system (Garud, 1997; Lundvall, 1996). From a management perspective, the capability of producing a particular product and the modification and enhancement of manufacturing processes are enabled through this type of knowledge (Matheus, 2009). Furthermore, the sharing and integration of know-what and know-why knowledge into manufacturing processes is an imperative management deliberation (Newell et al., 2005).

Know-why stands for an understanding of the principles underlying the structure of each component and the interactions between them (Garud, 1997). Know-why reflects the theoretical understanding of why the components of a particular product work together to allow a general purpose of a product, i.e. research and development (Sanchez, 1996). Know-why knowledge exists if an organization is able to modify a product design or to build up an innovative product design to make new product substitutes (Sanchez, 1996).

Many studies have focused knowledge at the technological level (Prencipe, 2005; Sapolsky, 2005). This study has considered knowledge more specifically in relation to manufacturing capabilities. Next section shed light on the methodological approach of this study.

Research Methodology

The purpose of the research is to refine current theory on the attributes of knowledge and to propose a process for competitive manufacturing capability development. Thus, this research is designed by composing multi criteria decision making of KM attributes so as to find their contributions to customer focus strategy through manufacturing competitive priorities. The decision making process follows Analytical Hierarchy Process (AHP) by seeking experts' choices on KM attributes and manufacturing competitive priorities as Figure 1 below.

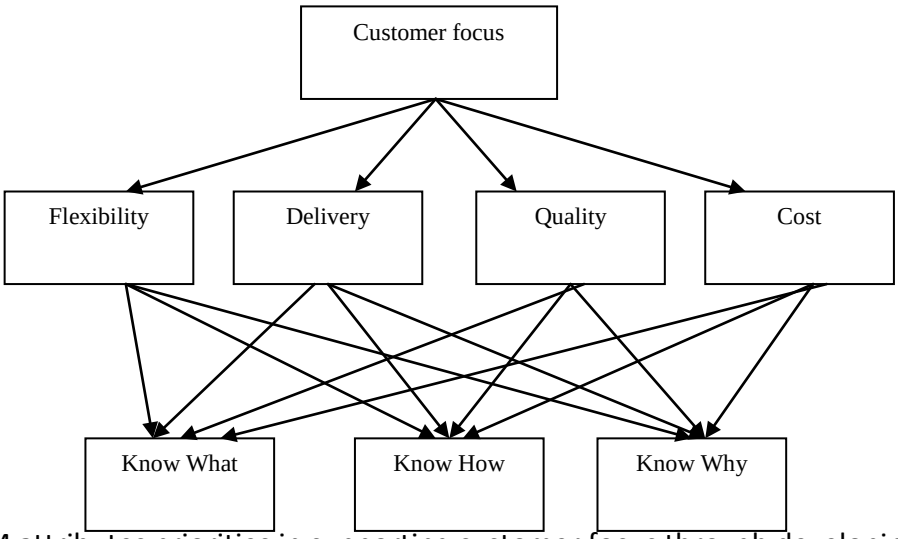

Figure 1: KM attributes priorities in supporting customer focus through developing manufacturing competitive priorities.

Data collection

Particulars of the manufacturing capabilities and knowledge attributes were collected from six manufacturing companies, three of those were small and three were large manufacturing companies situated in Finland. The size of the companies was determined by the number of employees. As explained by the European Commission (see Table 2). Small manufacturing companies were with less than 50 employees and large manufacturing companies were with more than 250 employees. Sample was taken by using same criteria for instance, the similarity of the operations, industrial sectors and corporate cultures of the small and large companies. Operation is defined as their daily manufacturing characteristic here.

The collected data were further analyzed by using AHP. The justification to use AHP is that it requires judgment from senior managers or directors of the companies. Thus, the clear understanding of the questions is strongly important to guarantee the reliabilities of the data. In addition, since the respondents are the key persons in the case companies so that we are confident about its validity.

Table 2: Company categorization (source: the new SME definition: user guide and model declaration, European Commission).

Enterprise category	Headcount: Annual work unit (AWU)	Annual turnover
Large	≥250	≥€ 50 million
Medium	<250	≤€ 50 million
Small	<50	≤€ 10 million

FINDINGS

Analysis is conducted by grouping companies into two categories, small and large size manufacturing companies and we get the results as follows.

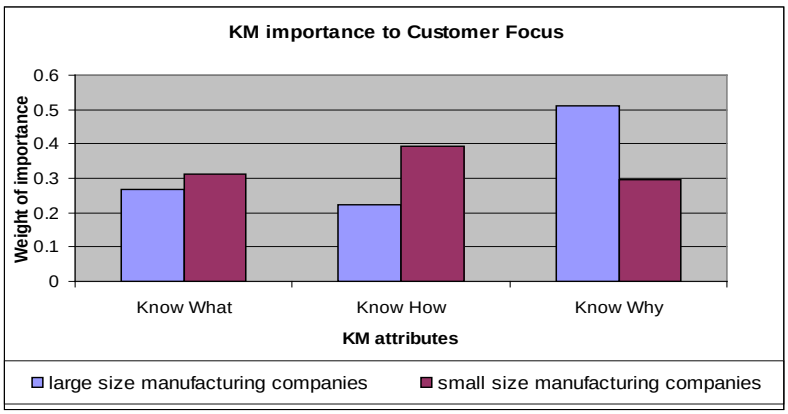

Figure 2: KM attributes priorities in large and small sizes manufacturing companies.

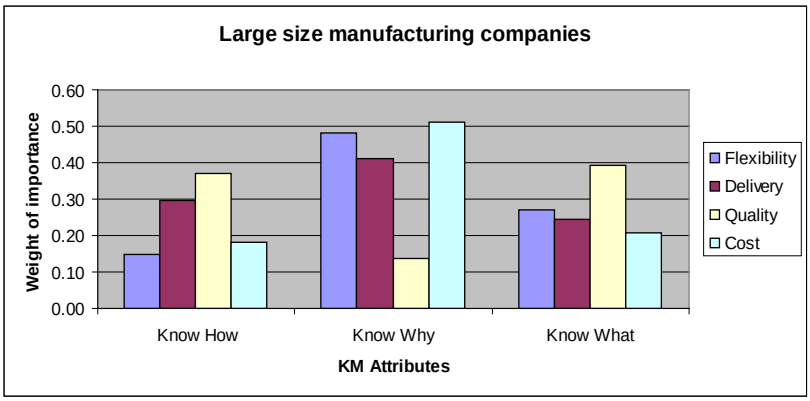

Figure 3: KM attributes priorities in large size manufacturing companies.

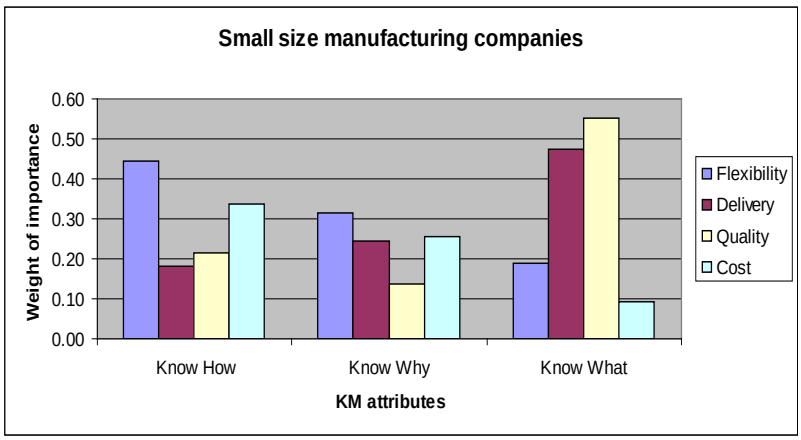

Figure 4: KM attributes priorities in small size manufacturing companies.

Above results show that large size manufacturing companies emphasize on Know-Why and Know-How for small size manufacturing companies as the most important KM attributes for supporting customer focus. Furthermore, this research found that large manufacturing companies putting higher know-why in all manufacturing capabilities as compared to small size companies. On the other hand, small size manufacturing companies putting higher know what in quality and delivery. This suggests that small companies KM is emphasized on routines for keeping their daily activities on the predetermined quality level while large size companies move further by finding the ways to achieve customer focus at the most efficient way.

Finally, this research also found that the both of small and large size manufacturing companies putting flexibility and cost as two most important manufacturing capabilities for supporting customer focus (Figure 5). This suggests that the both manufacturing companies sizes support leagile manufacturing strategy by meeting lean (cost) and agility (flexibility) as competitive advantage over competitors (Shariffi et al, 2006).

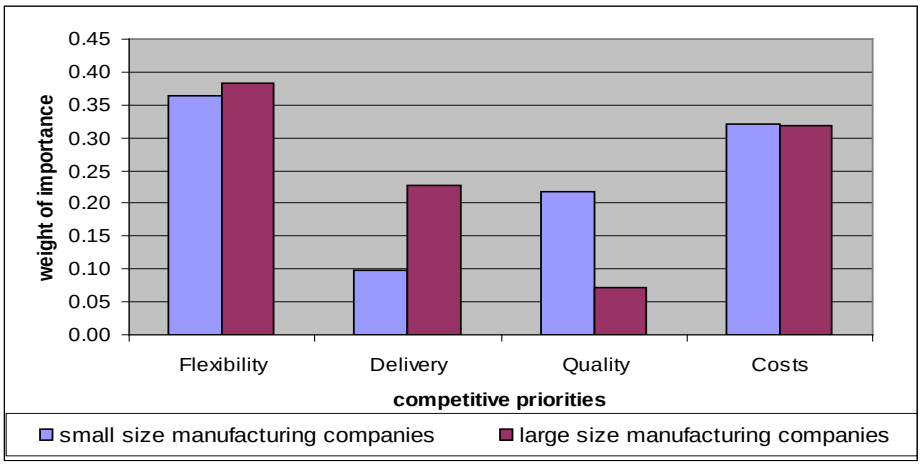

Figure 5: Competitive priorities of large and small sizes manufacturing companies.

CONCLUSION AND FUTURE RESEARCH

This research summarizes conclusions according to previous discussion:

1. Know-what knowledge attribute is for small size manufacturing companies and Know-why knowledge attribute is for large size manufacturing companies.
2. Cost and flexibility are two most important manufacturing capabilities for small and large size manufacturing companies.
3. Small manufacturing companies more emphasize on routine activities while large companies more emphasize on cost efficiency in achieving customer focus.

In terms of future research, it is important to extract further data from small and large manufacturing companies according to their order decoupling point in order to investigate knowledge attributes for different decoupling points. Furthermore, extending this research to service industry is also important to find competitive service strategy.

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B4 – Business process management

B4.1 **Theoretical reflections on business ecosystem – Case seminconductor industry**
Tuomo Kinnunen

B4.2 **A multi ERP implementation case for a firm striving survival in aircraft maintenance industry**
Dr. Farshad Salimi

B4.3 **Business process management: Barriers to maturity**
Lúcia Aparecida da Silva

THEORETICAL REFLECTIONS ON BUSINESS ECOSYSTEM – CASE SEMINCONDUCTOR INDUSTRY

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ABSTRACT

This paper discusses the structure and meaning of business ecosystem in business development, especially in value creation and offering development. The literature is reviewed for describing business ecosystem. Ecosystem metaphor emphasizes symbiotic relationships and dynamic nature of business network members. As a result semiconductor business ecosystem case is described based on information available in public. Companies need to understand their position and role in the ecosystem they are involved. Business ecosystem described through actors' business models defines the structure of the ecosystem and increases understanding of the ecosystem dynamics. Based on ecosystem description actors can analyze potential business development paths concerning company's offering and ecosystem value creation.

Keywords: Business ecosystem, business model, value network, semiconductor industry

INTRODUCTION

Networked business is the reality for most companies in any industry. Business ecosystems are composed of hundreds of and even thousands of organizations globally. (Dittrich and Duysters 2007; Iansiti and Levien 2004b) Individual companies are dependent on success of the whole aggregate and thus face a vast challenge in their business development. To thrive sustainably inside an ecosystem and in competition between rival ecosystems, development and innovation efforts of companies must benefit the ecosystem as a whole.

The metaphor of business ecosystem is derived from biology and used to describe business network originally by Moore (1993). The metaphor provides a vivid view on the nature of business network regardless of the fact that biology and business have not very congruent scientific basis (Corallo et al. 2007). This paper is built on idea that business ecosystem consists of interdependent business actors and "species" of each actor is based on its business model. Thus, business ecosystem can be described through actors' business models.

This paper contributes academic discussion of business networks by studying value creation and offering structures in a business ecosystem. Practical part of the study focuses on actors in semiconductor industry such as foundries, device manufacturers and design houses. The research focuses on business development in an ecosystem and answers to the research question: **How do the business models of actors describe a business ecosystem?**

This study reviews literature for the background. As a main theoretical contribution, a business ecosystem is described as composition of business models of actors. Theoretical background is reflected to practice with a case of semiconductor business ecosystem. The case is built on actors of semiconductor industry based on information available in public. Discussion is focused on business development in an ecosystem and conclusions are drawn against meaning of business ecosystem. The actors can utilize the study for creation and analysis of potential development paths within the ecosystem they are involved.

THEORETICAL BACKGROUND

Business ecosystem is largely overlapping concept with value chain and especially with value network. In general, all those concepts define how organizations are connected to each other to provide value to customers.

The idea of value chains is introduced as industry level approach where each actor, or a firm, adds value to the product (Porter 1985). In a value chain, organizations are horizontally linked to each other and each provides products or services to the next operator in the chain (Porter 1985). Value chain can be considered as a group of sequential activities, which can be connected through information and resource flows. The ultimate goal of a value chain is to provide value to the end customer of the value chain.

In contrast to value chains, in value networks the value created is not only for the customer, but also for firms and societies participating in the network (e.g. Parolini 1999; Bovet and Martha 2000). In value networks, resource and information flows can run vertically and horizontally. These flows can be simultaneous and multidirectional. Therefore, the value network could be rather described as a web than a funnel like value chain. The value network can be considered as a network structure where actors are linked, vertically and/or horizontally, to each other through value exchange activities. The ultimate goal of a value network is to provide value to the end customer and actors participating in the network.

In a business ecosystem it is always possible to identify value network or chain, the structure where actors are linked to each other through value exchange activities. However, ecosystem metaphor emphasizes network members' symbiotic, co-evolving relationships and dynamic nature of business network. Henceforth, business ecosystem is used to define business network in this study and business model is used to define actors of business ecosystem. Business model describes how a firm is creating and capturing value.

Business model elements and components

Business models are actively discussed topic in literature during last fifteen years. As a consequence, dozens of various business model concepts and frameworks exists including

up to fifty different business model components (Morris et al. 2005; Mäkinen and Seppänen 2007; Shafer et al. 2005). For this study couple of various and comparable business model definitions and frameworks is chosen for review. Those frameworks form a representative sample of literature since the origin and purpose of them are different.

Afuah (2004) defines a business model of a firm as a framework for money-making and explains business models as a strategic management approach. This framework is conceptualized through five main elements and embodies money-making aspects of strategies. According Osterwalder and Pigneur (2009) a business model describes the rationale of how an organization creates, delivers and captures value. Furthermore, Osterwalder and Pigneur (2009) explain the business model being like a blueprint for a strategy to be implemented through organizational structures, processes, and systems. It is broadly used model that is conceptualized through four main elements and nine building blocks. Shafer et al. (2005) define business model as a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network. This descriptive study is an example of many attempts to define business model by integrating and synthesizing earlier literature. According Suikki et al. (2006) business model describes the offering, the value chain or network, and revenue model of a firm. Suikki et al. (2006) designed their framework for describing and building business models in telecommunications industry. It provides an example of using business model for research purpose in industry settings. Frameworks are presented in Table 1 in terms of main elements and components.

Table 1: Business model elements and components in literature.

Author	**Main elements**	**Components**
Afuah (2004)	Positions	Customer value, market segments, revenue sources, price, relative position (vis-à-vis competitive forces)
	Industry factors	Competitive and macro forces, co-operative forces and industry value drivers
	Activities	Decisions of: Which activities to perform and which not, how to perform activities and when to perform activities?
	Resources	Resources (or assets: tangible, intangible and human), competences (or capabilities)
	Costs	Cost drivers of: industry, resource, activity and position
Osterwalder and Pigneur (2009); *Osterwalder* (2004)	Offer	Value proposition
	Customers	Customer segments, channels and customer relationships
	Infrastructure	Key resources, key activities and key partnerships
	Financial viability	Cost structure and revenue streams
Shafer et al. (2005)	Strategic choices	Customer, value proposition, capabilities/competences, revenue/pricing, competitors, output (offering), strategy, branding, differentiation and mission
	Create value	Resources/assets and processes/activities
	Value network	Suppliers, customer information, customer relationship, information flows and product/service flows
	Capture value	Cost, financial aspects and profit
Suikki et al. (2006)	Offering	Composition, customer and sales approach
	Value creation	Structure, players and size

	system	
	Revenue model	Basic logic, cost and pricing structure, market and share of value

Mäkinen & Seppänen (2007) concluded that literature of business models is diverse and lacks unified taxonomy and conceptual groundings. Besides differences in naming and in hierarchical classification, there is divergence also in actual content of business models. Inside a firm, business model concept is linked with and somehow positioned between strategy and operational level in which activities and processes are carried out (e.g. Osterwalder 2004). It is being argumented whether business model includes competitive strategy, value capture aspects of strategy or is like a blueprint of strategy (Afuah 2004, Chesbrough and Rosenbloom 2002, Osterwalder and Pigneur 2009). Furthermore, Osterwalder and Pigneur (2009) and Suikki et al. (2006) exclude strategy from business model itself. Relations to external environment and actors outside a firm are variously described and included in business models. Besides customers, perception varies which actors should be included in business model by default. In addition, approach to value creation varies from value network to be based on resources and activities. Relation to environment is overextended in Afuah's (2004) business model framework compared to others. Especially, the main element of industry factors and its components are not built into others' business model frameworks. This study distinguishes industry factors from business model because those factors are not describing how an organization creating and capturing value.

Description of business ecosystem

Moore (1996) defines business ecosystem as *"an economic community supported by a foundation of interacting organizations and individuals - the organisms of the business world."* In a business ecosystem, companies co-evolve capabilities around new innovations by working cooperatively and competitively to support new offerings, satisfy customer needs and eventually discover innovations (Moore 1993). Iansiti and Levien (2004b) define business ecosystem as "*loose networks – of suppliers, distributors, outsourcing firms, makers of related products or services, technology providers, and a host of other organization – that affect and are affected by the creation and delivery of a company's own offerings*." Originating from biology, an ecosystem provides a rich analogy for understanding business networks and symbiotic relationships of ecosystem members. Both business and biological ecosystems are characterized by a large number of loosely interconnected participants who depend on each other for their mutual effectiveness and survival (Iansiti and Levien 2004a).

Ecosystems have some specific features: the structure, the relationship among members, the kind of connections among members, and the differing roles played by their members (Iansiti and Levien 2004a). According Moore (1993) business ecosystem members can be classified as leaders, followers and business partners. The leader plays a role of central ecological contributor, and the role is valued by the rest. Followers need a leader and appreciate the leader because of its grip on customers (Moore 1993). Iansiti & Levien (2004a) identify keystone, dominator and niche player as particularly significant roles in business ecosystem. The roles are described in Table 2.

Table 2: Main roles in business ecosystem (Iansiti and Levien 2004a.)

Role	Description
Keystone	Fundamentally, a keystone acts to improve overall health of the ecosystem, and in doing so, benefits the sustained performance of the firm. It does this by creating and sharing value with its network by leveraging its central hub position in that network, while generally occupying only a small part of that network.
Classic dominator	Classic dominator acts to integrate vertically or horizontally to directly control and own a large proportion of a network. In so doing, dominators become directly and solely responsible for the majority of both value capture and creation in their ecosystem, leaving little opportunity for the emergence of a meaningful ecosystem.
Value dominator	A value dominator avoids control of the network and instead pursues control of value extraction alone. In so doing it provides little new value to its network, while at the same time capture most value for itself, leaving a starved and unstable ecosystem around it.
Niche player	Niche player acts to develop or enhance specialized capabilities that differentiate it from other firms in the network, leveraging resources from the network while occupying only narrow part of the network itself. Niche players constitute collectively the bulk of the healthy ecosystem in terms of total mass, value creation as well as variety.

According Corallo et al. (2007) parties in a co-evolutionary relationship activate selective pressure on the other, and consequently affect each other's evolution. Economical and social aspects are emphasized in business ecosystem; its evolution is due to competitive and cooperative interactions of its members. Members belong to an ecosystem for their own benefit and share the total value that the ecosystem creates. Each organization adds one or more distinct aspect of offering value to the value generated by the ecosystem. (Corallo et al. 2007)

Business model elements to describe ecosystem

In a simplified manner, *business model describes how a firm is creating and capturing value* (c.f. Shafer et al. 2005, Osterwalder and Pigneur 2009). Commonalities of business model can be identified although business model frameworks vary depending on source. As a summary and integration of literature, business model elements and components of are listed in Table 3 for describing a business ecosystem.

Table 3: Business model elements and components for describing business ecosystem.

Elements	Components
Actors	A firm, customer, co-operator
Value creation structure	Chain or network
Capabilities	Capabilities, activities, processes
Resources	Resources, competences
Offering	Offering
Revenue	Revenue logic, share of value
Cost	Cost of: resources, capabilities, upstream (suppliers, co-operators)

All studied frameworks identify customer and firm's offering that proposes value to customer. Offering is understood as source of revenue in this study and it includes

everything a firm can offer to its customers from raw material and components to products, services, tools and technologies. Value creation is build into all business models but emphasis is given on different aspects of it, such as resources, activities, value network and its participants. Costs are very basic element of all business models and costs result from other business model elements. For example, using and maintaining capabilities and resources, making acquisitions from value network and delivering an offering cause costs to a firm. Main actors in business model frameworks are a firm and customer. In addition, different kind of co-operators, namely suppliers, partners and players in value network are mentioned in literature. This elementary approach on business models is depicted in Figure 1.

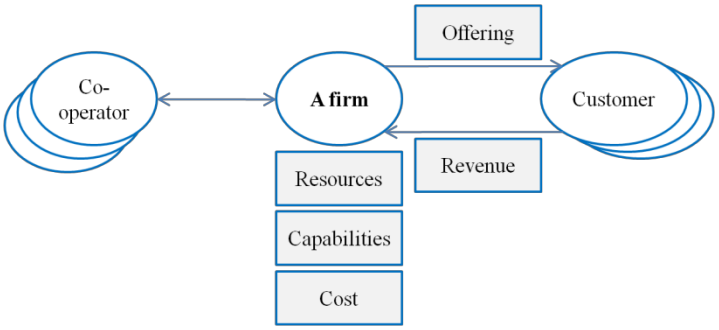

Figure 1: A business model framework and main elements.

The business model framework provides means to describe a firm and relationship between the firm and its customer. Describing business models of all actors in an ecosystem would provide a view on ecosystem in which actors are more or less interconnected to each other through customerships. Figure 2 introduces a theoretical view on business ecosystem based on actors' business models.

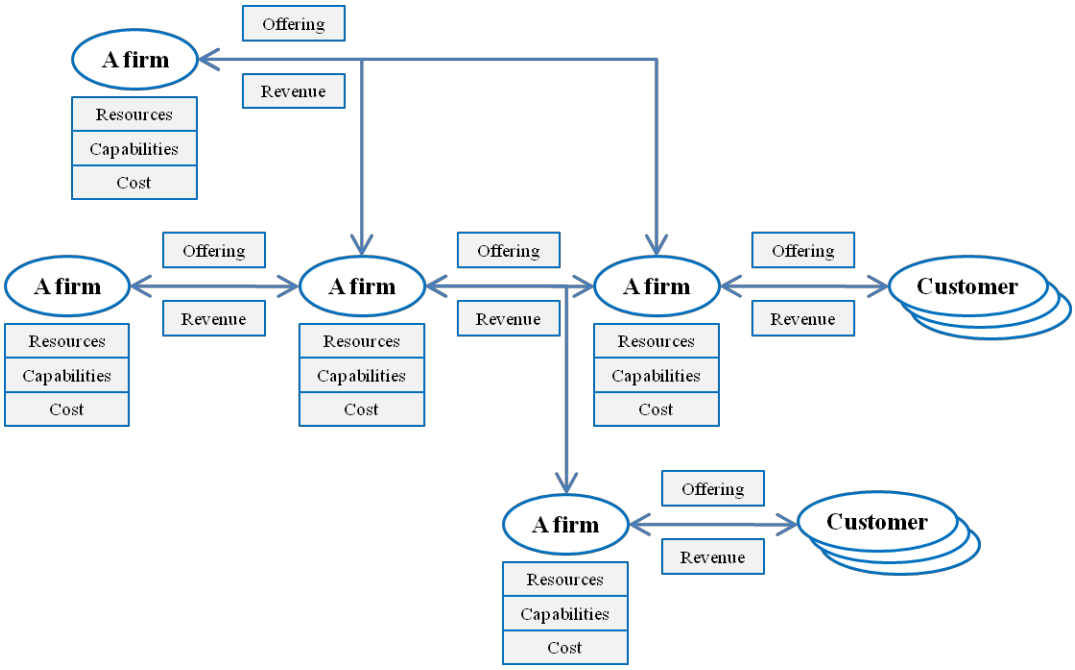

Figure 2: A theoretical view on business ecosystem based on business models of actors.

In a simplified manner, *business ecosystem is a loose network of interdependent business actors* (c.f. Iansiti & Levien 2004a). From theoretical perspectives, actors' business models

describes business ecosystem in several ways. Actors are connected to each other and ecosystem customers through relationships which are characterized by offering and revenue. Actor's offering describes value that the actor with its co-operators creates and proposes, and revenue is value that the actor captures from customers. An ecosystem offering is described as composition of the actors' offerings. Connections between actors describe value creation structure of an ecosystem. The structure of ecosystem can be a chain, a network or more likely mix of them. Position and necessity of each actor in an ecosystem can be changed over time and is determined by its resources, capabilities, offering and financial performance. Revenue gained by an actor has to cover costs of actor's resources, capabilities and upstream actors' revenue in order to survive in long run. Every business model elements has own role to describe business ecosystem.

By mapping each actor's business model one by one, the business ecosystem can be described as it is drawn in Fig. 2. If hundreds or even thousands of interconnected actors are fitted in the same view, the description of an ecosystem becomes very complicated. In addition, it could be impossible to draw exact boundaries of an ecosystem and figure out all the actors who belong to it. Thus, it might be reasonable to distinguish key actors from others, and consider "bulk" actors as groups when describing ecosystem. Business model elements, especially offering, capabilities, resources and/or revenue provide potential criteria for actors' classification and grouping.

CASE: SEMICONDUCTOR INDUSTRY ECOSYSTEM

Semiconductor industry overview

Semiconductor industry has evolved since invention of a transistor and an integrated circuit in some 60 years into a 300 BUSD yearly business. The industry itself serves other major industries like consumer electronics, information and telecommunications, transportation, medical, automation and energy industries. The industry provides fundamental enabling technologies for its customers and it has significant position in modern industry. The value chain of semiconductor industry is constantly evolving and roles of the actors in the ecosystem are changing (e.g. Li et al. 2011). Originally, so called integrated device manufacturers (IDM) dominated the industry due their strength in technology development for manufacturing processes, devices and applications. Over the years specialization took place as size of the required investments, capacity needs and diversity in applications and technological complexity increased (Ernst 2005).

Semiconductor industry ecosystem description

Semiconductor ecosystem can be fundamentally characterized as design and manufacturing ecosystem. It can serve or be part of other business ecosystems, such as ecosystems in consumer electronics or telecommunications. The ecosystem consists of various actors as described in Figure 3 (e.g. Ruippo 2005, Ernst 2005).

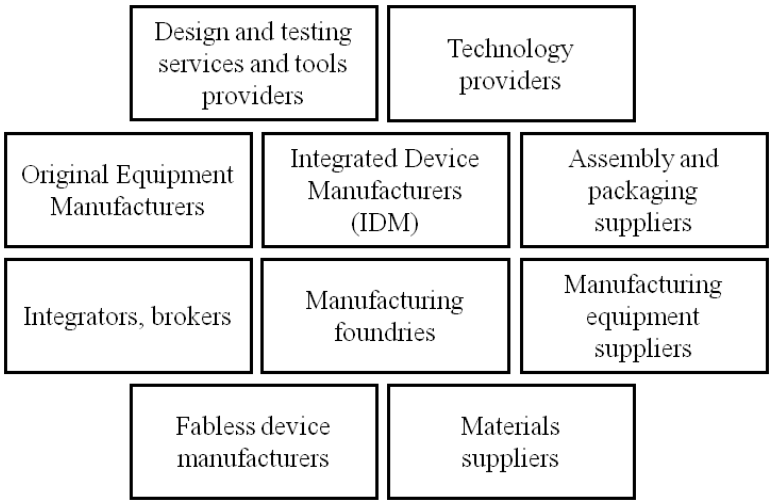

Figure 3: Main actor groups of semiconductor industry ecosystem.

In the ecosystem the original equipment manufacturers (OEM) are closest to the end users and applications served by retailers, services providers and public sector. Technical solutions, systems and devices are provided to OEMs by integrated or fabless device manufacturers, but may also be served by services providers, technology integrators or technology providers, which on the other hand provide their services to other actors as well. Manufacturing foundries provide manufacturing capacity, but also process technology and services to device manufacturers. Both independent and integrated foundries utilize materials and manufacturing equipment suppliers as well packaging services suppliers. Characteristic to the whole industry is that all actors may interact with each others, thus plentiful formations of value chains are possible.

In table 4 semiconductor industry ecosystem is described through the business model elements of its actors. In this study materials suppliers, manufacturing equipment suppliers and assembly and packaging supplier are omitted due to their limited role in serving only the ecosystem members who run manufacturing foundries. In the table, revenue and cost elements are not covered because these elements are by definition part of the business model description, but they do not specifically describe the ecosystem structure or function itself. Revenue and cost elements describe more the healthiness and dominance of actors in ecosystem value creation and value capture.

Table 4: Semiconductor industry ecosystem description by actor's business models.

Actor	Business model element		
	Offering	**Capabilities**	**Resources**
Original equipment manufacturer (OEM)	Ecosystem offering to customers and end-users.	Understanding end-user needs and solution development	R&D for product development, manufacturing operations, marketing
Integrated device manufacturer (IDM)	Devices to OEMs	Device technology and manufacturing process technology development, device development	R&D for devices and manufacturing processes
Fabless device manufacturer (FDM)	Devices to OEMs	Device technology development, device development	R&D for device development
Manufacturing foundry (FAB)	Manufacturing process technology and manufacturing capacity to IDM and FDM	Manufacturing process technology development	R&D for manufacturing processes, manufacturing capacity
Technology/IP provider	Technology to FAB, devices and OEM products	Technology development for devices and OEM products	R&D for product and device technology development
Design and testing services and tools providers	Services and tools for OEM, IDM, FDM, FAB, IP providers	Engineering tools and design methods for products, devices and manufacturing process development	R&D for engineering tools and methods; engineering services capacity
Integrators, brokers	IP brokering and integration services to ODM, IDM, FDM, FAB, IP providers	Engineering and IP acquisition for devices and OEM products	Engineering services capacity

In semiconductor industry ecosystem OEMs can be seen as the top of the ecosystem or the food chain, an actor group which the ecosystem is serving and finally dependent. In practice the semiconductor industry serves several types of OEMs which are acting in different end-user market segments or industries that utilize the semiconductor ecosystem. Therefore the industry is not dependent on only one group type of OEMs.

Integrated device manufactures (IDMs) can be seen as classic dominators which may occupy most of the value network. As only a few integrated device manufacturers can take care of and control almost the whole semiconductor value chain. If this kind of IDM acts as a classic dominator, there may not emerge meaningful ecosystem around it since majority of value capture and creation is based on the actor's own business model. In practice, the variety of applications and device market segments, and complexity of technologies have forced IDMs to act as a keystone, thus enabling emergence of niche players. Actors like technology and IP providers, integrators and services providers can be regarded to locate at the bottom of the ecosystem serving as niche players the rest of the ecosystem members, even directly the OEMs at the top of the system.

Also manufacturing foundries are acting like keystones for the entire ecosystem, enabling also emergence of fabless device manufacturers (FDMs), which consequently foster existence of niche players while competing against IDMs in serving the OEMs. Some specialized materials or IP suppliers might be able to gain a value dominator position, which could endanger healthiness of the entire ecosystem.

A semiconductor ecosystem with strong keystone players like IDMs and FABs is beneficial for all actors by thriving in competition and gaining more profit and revenue. Such ecosystem can create and capture more value than actors alone and produce wider variety of offerings and serving more OEMs, and thus serving end user applications in variety of market segments and industries. From table 4 it can be seen that business models of actors define a business ecosystem of keystone, classic dominators and niche players.

DISCUSSION

Business ecosystem that is defined systematically through actors' business models provides means for actors to analyze and develop business. At first, describing an offering actor by actor provides a rich perspective on composition of the ecosystem offering and the value that each actor adds to the offering. Then, defining ecosystem value sharing by actors' revenue and cost elements enables comparison of actors' financial performance. This information can be used for refining revenue logic and optimizing the cost structure of an actor.

Capabilities and resources are main distinctive factors between actors in an ecosystem and essential characteristics for explaining each actor's position and necessity in the ecosystem. For example, a niche player aims to develop specialized capabilities to add necessary piece of value to ecosystem offering. Strong actors hold and develop critical resources for ecosystem and they can behave as dominators or keystones in ecosystem based on behavioral roles (table 2). Strong dominating actor can hinder ecosystem development. With strong keystone players an ecosystem can create and capture more value than actors alone and produce wider variety of offerings in long run.

Having actors with diverse roles, strategies and business models is a precondition for meaningful business ecosystem. Significant role changes can be hardly done without rethinking a firm's strategy and furthermore, business models. After deciding the role to play in an ecosystem an actor may seek development paths that shape its performance and increase consistency of elements in business model. Actors' strategies and realization of strategies through business models determines how an ecosystem can evolve. Success of a business model can be proved only by testing it in practice. Dynamics and structure of business ecosystem should be considered when making business development decisions concerning strategy and business model.

CONCLUSIONS

Business ecosystem is a loose network of interdependent business actors. By defining each actor's business model one by one a description of business ecosystem is built. Actors' business models explain relations between and roles of actors. This study defines business

models systematically through elements, such as resources, capabilities and offering that are common for all actors. Each business model element has own role in the ecosystem description.

In business ecosystem described through business models, actors are connected through relationships which are characterized by offering and revenue in business models. An ecosystem offering is composition of the actors' offerings. Based on connections between actors, value creation structure of an ecosystem can be formed as a chain or a network. Position and necessity of each actor in an ecosystem will be changed over time and is determined by its resources, capabilities, offering and financial performance.

Dynamics and structure of business ecosystem should be considered when planning and making business development in a firm. Business ecosystem as described in this study is useful for ecosystem actors for that purpose. However, this description cannot predict evolution of business ecosystem that is dependent both on environment the ecosystem is working as well as actors' capabilities to innovate.

This study draws a generic view on defining and describing a business ecosystem. Validation of results is largely dependent on further research and practical applications. Further research could be done through in-depth case studies on business ecosystem.

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A MULTI ERP IMPLEMENTATION CASE FOR A FIRM STRIVING SURVIVAL IN AIRCRAFT MAINTENANCE INDUSTRY

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ABSTRACT

This peculiar case study reviews a three stage ERPs implementation of major ERP packages at a survival firm in a shrinking market. The firm rationalized the process of ERP implementation as the key competitive advantage against its global competitors. The firm strived for efficiency by ERP implementation of three packages; SAP R2, BaaN IV, and Pentagon in a continuous improvement process. We identified the management involvement, project management, management control and ownership, recognition of striving for the organizational fit, strategic IT integration, and personnel dedication as key critical success factors (KCSFs) with in particular personnel dedication and their valuable contributions to changes.

Keywords: ERP Implementation, Key Critical Success Factors, Manufacturing, Service Industry

INTRODUCTION

The Enterprise, FKS.

FKS is part of the SK Aerospace Services division of SK Aerospace group. FKS has four business units for aircraft support services (AS), material support (MS), component support services (CS) and technical support services (TS). AS business unit core business is selling maintenance hours for aircraft maintenance in the base and out-of-stations; i.e. aircraft conversions and modifications; damage assessments and repairs; and painting aircraft. This core business concentrates on the Fokker aircraft market as the focus point in this case study. FKS was seeking new business in maintenance of Boeing, Embraer, Gulfstream aircraft, and in the combat aircraft market (F16). This case study investigated the application of ERP in the earlier and future FKS positioning, with a focus on one of its four strategic business units (SBU), i.e. business unit aircraft services (AS).

FKS Strategic Objective

FKS is an integrated knowledge based service organization that works in partnership with both the owners and operators of the aircrafts. FKS is an organization that enables the customers to have maximum availability of their regional aircrafts at the lowest possible costs while maintaining a profitable business. The intended Maintenance, Revision & Overhaul (MRO) partner must be able to deal with four key issues of technology, logistics, process and people from the airline carriers' MRO perspective. The carriers look for reductions of fixed MRO costs. They rationalize on direct MRO costs (i.e. staff, spare-parts, process management, resources, IT costs and so on), and on increased efficiency and flexibility in MRO activities.

FKS followed a unique rationalization approach by restructuring its internal processes for cost savings across the supply chain with external orientation towards the suppliers and clients i.e. inbound logistics and outbound logistics. The FKS core business offered complete services in aviation MRO with a "one-stop-shop" philosophy. FKS's target market was the FKS aircraft market with nearly 1100 aircrafts worldwide. In three phases of the restructuring process, FKS changed its ERP system from SAP R/2 to BaaN IV and then to Pentagon in order to achieve three objectives of (a) continuous improvement, (b) new business strategy, and (c) organizational fit.

In the course of ERP Pentagon implementation, FKS carried out a business case analysis in order to improve the chances of success in the post Pentagon implementation period.

PROBLEM DEFINITION AT FKS

FKS restructured its business processes on a continuous basis to comply with the upcoming internal and external clients' demands. After FK Aircraft bankruptcy, FKS, as an independent service provider, faced a total close down because of the decreasing number of FK aircraft in operation, and later due to September 11th impact on the MRO market. For a sustainable business, FKS searched for new ways of conducting business in new markets. Due to changing market, FKS searched for new objectives, new strategies and operational key critical success factors.

Because of the shrinking market, the AS MRO maintenance revenue had fallen from one million hours in 1992 to approximately four hundred and fifty thousand hours in 2002.
In the same period, FKS sales breakeven point rose from 500000 maintenance hours to 600000 maintenance hours.

Reasons for Changes

Because of its weak financial results, FKS anticipated shortcomings in its organizational structure and its market approach in aviation market. Therefore, the market approach had to be reengineered and objectives had to be reset to improve its market positioning. An internal and external analysis provided FKS with project goals in continuous reengineering of processes in: increasing the market share to a minimum of 25% to achieve the breakeven point; lowering internal costs by at least 20% in order to obtain a competitive man-hour cost price rate; speeding up the request for quotation (RFQ) processing; creating more transparency in processes; presenting mission and vision of FKS as a unique MRO supplier in the market, and developing and promoting a partnership attitude across the supply chain with suppliers and clients. For this reason, the markets perception of FKS had to be changed from an e-shopping mall, i.e. irregular, incidental and partial sales (Figure 1), to a potential partner for airliners in the MRO market, i.e. organized total package sales (Figure 2).

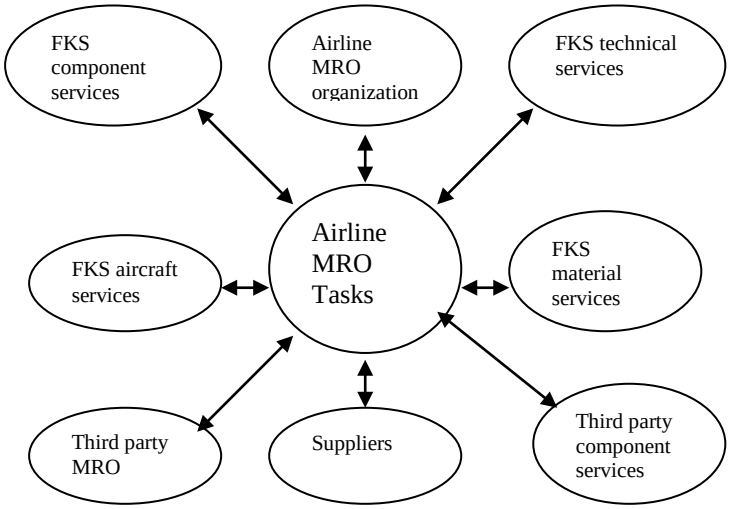

Figure 1: Airline market behavior and airline MRO outsourcing structure.

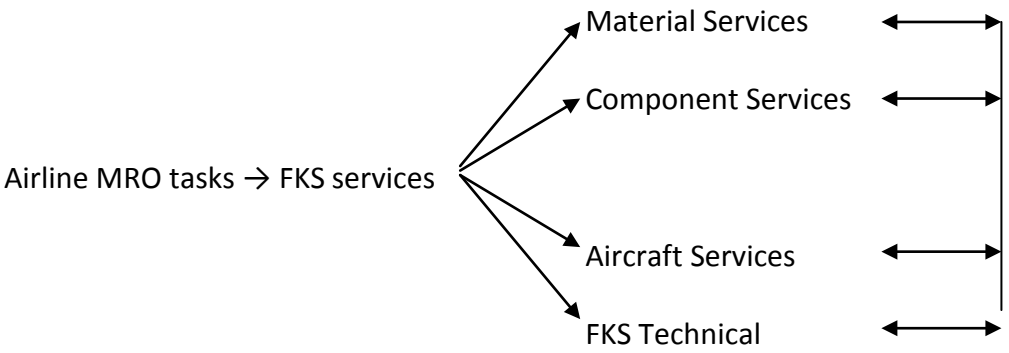

Figure 2: New business structure-partnership and collaboration.

FKS achieved four key issues in its restructuring processes; (a) internal and external integration of the four SBU's, (b) knowledge sharing with the client, (c) partnership with owners and operators, and (d) development of an active competitive advantage for each operator.

Market Threats

The crisis in external market provided new opportunities for FKS to benefit from. The airliners' MRO expenses were costs without yield; therefore, the costs needed to be as low as possible with the quality of maintenance and safety complying with the best standard practices. Traditional maintenance requires heavy investments. Airliners make tremendous MRO costs to anticipate the unpredictability of high quality and safe aircraft maintenance. The main MRO cost barriers are: manpower, logistics, tooling, IT costs and hangar availability. Although, all these key items are essential parts of the maintenance process, they have not always been utilized actively for the MRO activities. The improvement and utilization of these resources in an efficient way could result in a drastic reduction in the fixed MRO costs. Both MRO service providers and their clients, i.e. airliners, anticipated to

improve their positions in the market by sharing; (a) manpower, (b) logistics, (c) tooling, (d) IT costs, (e) hangar availability, and (f) other fixed costs. FKS competitive position was vulnerable. Reorganizing its business processes, structure, and market approach was the only business solution to strive for in the declining market.

BUSINESS SOLUTION AT FKS

In the past, FKS had focused on restructuring its internal processes at back-office and its related applications. These changes were essential for the switch over from SAP R/2 to BaaN IV due to Y2K problems with the SAP R/2 system. An explicit change of focus was apparent, from internal processes to external processes with the clients and suppliers. The external relations with the clients and suppliers became more important, and the internal automation was no longer the most important critical issue at FKS.

Project Goals (Restructuring)

Among the external threats FKS identified; presence of intermediaries, presence of other on-line service providers with in particular second hand brokers, low man hour rates in eastern and southern Europe, decreasing number of Fokker Aircraft in operation, declining American market share on the MRO due to Sept 11th, and an increase in "stand-alone" maintenance providers looking for MRO works. At the same time FKS identified new opportunities for profit due to; growth of the aircraft market in the Far East and Eastern Europe; development of digital salesman (lowering fixed costs) by the Fokker site, split of maintenance work from the core business by airliners, application of ERP by airliners, and lower transaction costs for FKS by increasing e-applications.

FKS manifested the necessity to target three main objectives of; (1) decreasing internal overhead costs, possibly through cost and efficiency drivers; (2) restructuring and ERP orientation at in/outbound logistics, referring to the two key areas of the procurement process and sales process; (3) sharing MRO data with airliners to increase MRO market share, being more transparent in processes and costs, being more market competitive, and by offering real partnership to the clients. To achieve these objectives, there were four main areas of focus in its MRO market positioning:

1. Maintenance Management: It is the support by skilled and certified aircraft maintenance technicians and services.

2. Engineering and Planning: This is the know-how to define aircraft configurations, maintenance programs, work requirements and associated documentations to meet regulatory and MRO specifications and operator needs. It is the ability to plan and schedule effective utilization of all resources including aircraft, materials, tools, people, and facilities.

3. Information Technology: This is the technology to manage, track and communicate across logistics, procurement, supply chain and mechanics, with the goal to make maintenance more predictive for client and vendor. Ideally, a service provider will electronically integrate an airline's flight scheduling and other information systems, for its overall operation and customer service.

4. Supply Chain: It is effective procurement, inventory, warehouse and transportation management processes, including a resource strategy, which will allow operations to be more efficient. With an aggregated supply chain, purchasing power is increased and inventory can be optimised across multiple carriers.

FKS offered four items as four individual items and not as a package to the market. The ERP was a tool to change the heading towards a complete and synergic MRO approach to the market.

After review, AS decided on the following six main conclusions and related recommendations: (a) *Growth through unity,* the growth of AS was possible through the unity of the four strategic business units of FKS, (b) *Synergy improvement,* the "four different companies with their own core-businesses" perception must be changed into a "one company-one core-business" perception, (c) *Internal integration*, the unity and synergy between the four SBUs, the world-wide scattered clients and the magnitude of the MRO data stream was only qualitatively manageable by ERP implementation and a well thought-out implementation strategy; (d) *External integration,* streamlining all FKS internal organizational processes and elements of the value chain network towards a full integration, (e) *Culture change*, changing corporate culture and adapting business-processes towards partnership were major KCSFs in improving its competitive position, (f) *E-Business development*, Incorporating e-business strategy as part of the traditional business strategy would also improve the traditional business strategy. In a continuous improvement process, for each of these items a thorough and detailed plan was developed with respect to ERP risk management and return on investment.

THE BUSINESS (RE) ENGINEERING PROCESS AT FKS

FKS worked towards client demands and reengineered its current business structure to adapt its processes towards a smooth integration with the clients. The maintenance value chain presents the added value contribution that Fokker Services could provide with an ERP application to its clients.

The maintenance value chain at FKS consisted of the following elements:
Maintenance Request → Trouble Shooting → Repair Order → Logistics Needs → Skilled Engineer Planning → Hanger Slot Reservation → Actual Repair Process → Testing → Closing Maintenance Request → Data Processing and Managing.
There were four possible maintenance options for FKS (Table 1);

1. Daily scheduled maintenance,
2. Daily unscheduled maintenance,
3. Periodical scheduled maintenance,
4. Unscheduled maintenance.

Each individual maintenance inquiry represents a process segment to four sub-chains of: Technology, Logistics, Process and Labor.

In turn these sub-chains were segmented into predictable and unpredictable key issues. The added value in processes could be obtained through decreasing the unpredictability, and supporting and encouraging partnership with the airliner. The maintenance value chain was designed in such a way that the same processes were present for all four possible maintenance options. After analysis of the maintenance value chain, FKS found the logistics support and unscheduled maintenance as the items to focus on. Since unscheduled repairs contributed to a dominant part (90%) of scheduled maintenance, this part of the chain was also important due to its unpredictability. Furthermore, the main items in the value chain difficult to predict were: Logistics (i.e. flow of spare parts and components-inbound logistics) and Labor (i.e. planning hours and allocation of man-hours). These two high cost items in the airliner business covered a substantial part of the airliner expense budget (12-15%) on MRO costs. Furthermore, it was striking to find that both "processes" and "technologies" were highly predictable in daily and periodical scheduled maintenance (table 1). The reason was the regulations dictated by authorities and the worldwide standardization of aviation maintenance.

In its new structure, FKS required only one design in maintenance processes for all four options resulting in benefits in design-costs and users ease.

Table 1: Maintenance Options.

TECHNOLOGY - LOGISTICS - PROCESS - LABOUR			
DAILY SCHEDULED MAINTENANCE			
Highly predictable	Highly predictable	Highly predictable	Highly predictable
DAILY UNSCHEDULED MAINTENANCE			
Highly predictable	***Unpredictable***	Highly predictable	Predictable
PERIODICAL SCHEDULED MAINTENANCE			
Highly predictable	***Unpredictable***	Highly predictable	***Unpredictable***
UNSCHEDULED MAINTENANCE			
Predictable	***Unpredictable***	Highly predictable	***Unpredictable***

ERP PACKAGES

ERP SAP R/2

At the time of our research, FKS was equipped with the SAP R/2 maintenance module to support its primary processes at MRO aviation services. The internal processes were modified prior to the SAP implementation. In this context, FKS strived for survival in the competitive market through internal cost savings measures. This measure was the primary reason for the ERP adoption as a whole.

ERP BaaN IV

In 1998, the management complemented the changes with implementation of another ERP package due to Y2K. Although the millennium problem was the main reason for the new ERP adoption, the report structure of SAP R/2, organizational fit and its fit to FKS internal processes also motivated the changes for a shift from SAP R2 to BaaN IV.

The customization of the SAP R/2 report structure and of the maintenance module into the business processes was no longer the only issue.

Reasons for the Changeover from ERP SAP R/2 to ERP BaaN IV

At FKS, the reasons for a new ERP adoption were Y2K and the misfit of the SAP report structure (s*hortcomings; low level, low quality, with no total overview of available information, and incomplete management report*). To change the ERP package, FKS benchmarked its ERP SAP with the other operating models. The objective was to find the best fit to FKS primary processes. The scope of implementation was replacement of the outdated ERP system, SAP R/2, with the BaaN IV system. Among other factors justifying this decision, the FKS quoted that "*First of all SAP was not a millennium proof package and the new version of SAP was not ready for implementation at the time and mother company SK was ready to switch from SAP over to BaaN IV for the entire organization. In a way, our business unit was pushed to switch over to BaaN IV. "*

Main Internal Processes at ERP BaaN IV

In the process of implementation, the main processes were identified as sales, projects, work preparation, MRO works, aircraft test, technical certification to authorities and project management. The main internal processes were logistics, control of shop floor, planning and report structure.

The project management progress reports played a key role in the success of the ERP BaaN IV implementation. During the one-year implementation period, FKS invested eight million euros in ERP implementation. The immediate intangible benefits were stock control, reporting, scheduling and planning.

The overall improvement in the system was in project control, reporting structure and speed of processes. A full-scale implementation plan was outsourced to an outside consulting company. However, FKS suggested that; "*the degree of training provided by the consultant for the new system was inadequate".*

Reasons for Changeover from ERP BaaN IV to ERP Pentagon

The FKS stated that "*In our view, BaaN IV did not meet the user expectations and intangible benefits, if any, they are hard to point out. In fact, one of the reasons to look for another system was the continuous costs associated with updating and changing (customization) the BaaN IV software up to our actual requirements.*

Even after the changes and adjustments, a lot of reports were just nearly 'good reports'. There was no major improvement in working with BaanN IV in comparison with its predecessor, SAP R2. Another major barrier with BaaN IV software was its configuration which was primarily made for maintenance services within the aircraft manufacturing industry (e.g. Boeing etc). "

In view of the above shortcomings mentioned, FKS decided to switch from BaaN IV to the Pentagon ERP system. The selection of Pentagon was a bottom-top technology strategic approach. FKS stated: "*It was the users' request to change over to Pentagon. It was, of course, the management decision to proceed with the change over."* BaaN originally designed an ERP manufacturing package, BaaN IV package, in partnership with Boeing to support the Boeing manufacturing system. Thus, the ERP MRO module did not fit directly into FKS operations; however, it was the closest match in organizational fit that FKS could find in the market. Pentagon was the new generation of a customized MRO package in aviation services. FKS finally replaced the earlier ERP BaaN package with Pentagon.

ERP Pentagon

Pentagon is a U.S. based IT firm specialized in aviation maintenance software and FKS was its first European client. Over the years, FKS spent its resources in restructuring its internal processes for the back-office systems and its related applications. This was necessary for the continuation of the processes after the change over from SAP to BaaN IV due to millennium impact.

This change was an explicit shift in focus from internal processes to external processes. In other words, the external relations with customers and suppliers were at the centre of the changes. FKS worked on the total integration of its business processes with clients and suppliers. This was to fulfill the FKS business strategy from cooperation to collaboration and partnership with the suppliers and clients.

"*The aviation industry is a complex business with respect to traceability of parts, components and tasks responsibilities. The Pentagon program seems to be the first program, which fulfils our requirements in the complex maintenance process*." This conclusion was based on the fact that the use of the Internet Application turned FKS into an e-shopping mall for airliners. The restructuring business strategy was to present the four business units as one to clients while clients only made use of services of one unit at a time. This client behavior had turned FKS into a kind of MRO discount centre.

Project Goals (Pentagon)

The project goal was integration of internal processes to external processes, e-strategy synergy, partnerships, and sharing information and knowledge across the supply chain with global clients. The external focus was on the customer side of the MRO value chain.
A marketing SWOT analysis by FKS identified those key areas in customer relationship together with the new opportunities in the market.

Tangible and intangible benefits (ERPs)
FKS expected that the fulfillment of project goals would lead to lowering MRO fixed costs (i.e. the costs of manpower, logistics, tooling, IT costs and hangar costs).

Onward and upward phases -Post Pentagon implementation business analysis
Figure 1 shows how the clients used the four SBU's of FKS frequently as four separate services while the SBU´s had the objective of working as one unit to the clients.

The clients used the most attractive parts out of the four SBU's in any inquiry. Because of this market behavior FKS had changed into a kind of MRO discount centre. In this format of outsourcing market to airliners, FKS only provided one of its capabilities with one option out of a multiple capabilities of MRO options to its clients.

CONCLUSION

Finally, the FKS case was a very special case with a remarkable struggle following a holistic, from global collective knowledge, and embedded, own innovative initiative, approach through three restructuring and ERP implementation processes in SAP R2, BaaN IV, and Pentagon. The firm strived for efficiency by ERP implementation in a tough shrinking competitive global market. We learnt about a number of KCSFs, with in particular personnel dedication and contribution to changes. The firm built up a particular experience in ERP implementation processes, from which we could all learn. They continued benchmarking these experiences in a continuous process of changes.

KCSFs

The relative benefits of ERP implementation at FKS were related to the following KCSFs: the management involvement, project management, management control and ownership, recognition of striving for the organizational fit, strategic IT integration, and personnel dedication.

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BUSINESS PROCESS MANAGEMENT: BARRIERS TO MATURITY

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ABSTRACT

Purpose: The migration from traditional management model to business process management (BPM) results on one hand in improvements in the process performance, and on the other, it promotes an increase in management complexity. Thus, there are restrictions or barriers to be overcome for the successful implementation of the new management model. The aim of this study was to assess the maturity level of companies in relation to business process management and identify the main barriers found in changing the management model. Design / Methodology / approach: a case-study with two companies operating in the service sector was conducted. In-depth interviews with managers of the companies studied were made. The interview used was structured in three blocks that corresponded to three task groups developed by Paim, Caulliraux and Cardoso (2008). Findings: It was found that these companies are at different maturity levels in relation to the business process management and people and organizational culture are present in both organizations as challenges to change the business process management model. Research limitations / implications: The research is based on an extensive bibliographic database with limited capacity of empirical validation. Originality / value - The paper describes an unprecedented empiric study in terms of BPM maturity and barriers to be overcome to implement the new management model. The survey does not only investigate which BPM tasks are performed, what is the importance of each task and which are the main challenges.

Keywords: Business Process Management, Business Process, Maturity level, Barriers in process management.

INTRODUCTION

Constant changes and growing competition are part of the reality of all companies, regardless of productive sectors, size or location. There is a trend of companies opting for a business process management structure rather than the traditional functional structure, due to factors such as: increased frequency of ordered products, need for rapid transfer of information, rapid decision making, need to adapt to demand changes and an increasing number of international competitors (Seethamraju and Marjanovic, 2009).

Neubauer (2009) highlights other challenges that companies are recently facing, including the ever-changing business requirements, decreased product life cycles, international competition and pressure of rising costs.

Thus, BPM is not only important for transparency in the company's internal environment in a context of changing economic environment, but it is also a way of dealing with the challenge of improving the company's business processes in order to optimize its performance (Trkman, 2010). In this sense, the focus of the organizations must be processes that add value to their customers (Kohlbacher, 2010).

To Neubauer (2009) and McCormack et al. (2009), the business process management (BPM) allows companies a quick organizational adaptation. Liu, Li and Zhao (2009) report that BPM enables organizations to create dynamic and flexible collaborations to synergistically adapt to the conditions of changing globalized market.

BPM provides the development and continuous improvement of business strategies and makes companies to focus on generating value for customers and improving their performance (Mccomack et al., 2009).

Houy, Fettke and Loos (2010) conducted a survey in order to provide an overview of the evolution of empirical research in business process management and concluded that the increasing number of articles published in journals, conferences on the subject and the institutionalization of graduation programs focusing BPM at several universities show that BPM is not a fad but a trend to progress to the administration science.

Neubauer (2009) reports that although the business process management is among the most important management issues because it allows companies to adapt rapidly to changing business requirements, only a very small number of companies follow a holistic approach and reached the status of companies focused on process.

Then, it becomes necessary to check how mature the companies are in relation to processes, and to meet this need, there are maturity models that, according to Jeston and Nelis (2006), are tools designed to assess the maturity level of organizations and help them achieve greater business benefits through the successful management of their processes. According to McCormack et al. (2009), reaching greater maturity in the business processes management, the organization will have better control of results, better forecasting of goals, costs and performance, will gain more efficiency to achieve the defined goals and improve the ability to propose new solutions.

But if on one hand, the migration from traditional management models to business process management results in improvements in the performance of processes, on the other, it promotes an increase in management complexity. Thus, there are restrictions or barriers to be overcome for the successful implementation of the new management model.

These barriers can be linked to the business segment, to people or to the company. The main barriers found in literature are: issues related to technology, the organizational culture, lack of knowledge about the concept of processes, little integration between methodologies, techniques and tools employed in the several areas of the company, lack of basic knowledge on business process management by all of the organization, lack of direct involvement of leadership and executive staff, lack of incentives and rewards to encourage the adoption of

new processes, and lack of essential resources to BPM or their mismanagement (Antonucci et al, 2009; Bandara; Gable; Rosemann, 2005; Bandara et al, 2007; Trkman, 2010).

According to Jeston and Nelis (2006), Trkman (2010) and Neubauer (2009), the importance of BPM leads to the question of how organizations are advanced in their BPM development, since BPM is a complex practice, and many organizations find it difficult to implement it to evolve to higher maturity levels.

Since there are few publications of case-studies on how organizations are advanced in relation to the business process management and the barriers faced to manage the process (Neubauer, 2009; Trkman, 2010), the general objective of this study was to assess the maturity level of the companies studied in relation to business process management and identify the main barriers found for the migration from traditional management model to business process management.

To achieve the objective of this study, a literature review was initially performed to learn about the fundamental concepts related to business process management, maturity in business process management, tasks related to business process management and barriers faced by companies to achieve higher maturity levels.

In-depth interviews were conducted with managers of two companies from the service sector using the instrument validated by Paim, Caulliraux and Cardoso (2008) as a guide. The data obtained were used to perform qualitative analyses that allowed the achievement of objectives.

Given the importance of what has been discussed above and due to the scarcity of studies that address this topic as the study by Trkman (2010), this paper intends to bring contributions for both professionals and academics, in terms of the BPM maturity and barriers to be overcome to implement the new management model.

THEORETICAL FRAMEWORK

Business Process Management

BPM is not just about designing, developing and implementing business processes, but more than that, it is to consider the interaction between these processes, control them, analyze them and optimize them, and, according to Kohlbacher (2010), the biggest difference between BPM and BPR concepts is that the former refers to the company management based on business processes, and the latter deals about a radical project of redesigning business processes.

According to Jeston and Nelis (2006), BPM can be defined as a practical holistic approach of organizational management where factors such as the understanding and involvement of senior officials, clearly defined roles, appropriate techniques, well-trained people and a culture receptive to business processes are critical to obtaining the desired result.

Trkman (2010) adds that BPM can help in implementing a strategic program, allowing a better match between organizational strategies and the company's business process. In this context, Ravesteyn and Batenburg (2010) suggest that when organizations start the implementation of BPM systems, they must realize that this is not an IT project, and that they should be based on the business goals due to its strategic relevance.

According to Antonucci and Goeke (2011), there is still no universally accepted definition of BPM; however, experts generally agree that BPM has evolved from a guidance for systems (technology) to a management practice in which the company has its processes customer-focused, with goals, people and technology focused in both strategic and operational activities. Therefore, for these authors, BPM is a discipline that integrates technology information and knowledge of business processes with the aim of transforming isolated efforts into integrated and measurable activities that provide competitive, operational and strategic advantages in order to obtain a holistic view of the end-to-end planning and management of business processes.

However, changing the functional structure of the company into a process structure means not only defining the responsibilities for the progress of processes, minimizing transfers, and thereby reducing errors and delays, but also maximizing the grouping of activities and reducing efforts.

According to Paim, Caulliraux and Cardoso (2008), in the functional management, processes are managed separately; the organization has characteristics of silos with low capacity of coordination and this approach shows low market orientation. In the business process management, there are changes in organizational structure and in other organizational elements aiming the prioritization of processes as a management axis of higher importance than the functional axis, thus guiding decisions whose priorities are processes. Figure 2 shows the spectrum of organizational decision-making of functional management versus business process management. In can be observed that in business process management, the decisions and the structuring of elements shown in Figure 1 are process-oriented.

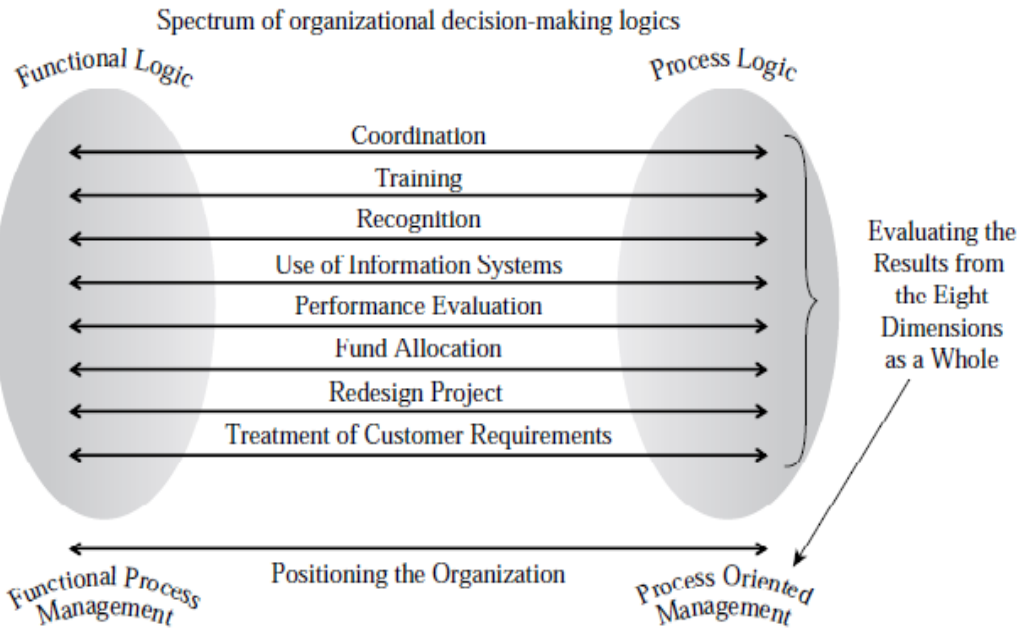

Figure 1: Spectrum of organizational decision-making: functional management versus business process management. Source: Paim, Caulliraux and Cardoso (2008), p. 709.

According to Jeston and Nelis (2006), the organizational change management represents the most important component of BPM implementation, because the involvement of people and the leadership of line managers are critical success factor to achieving the desired involvement. Palmberg (2010) shows that when the functional and hierarchical organization meets the new process-oriented organization, there is a clash between people who prefer to take orders and those who prefer greater responsibilities, and a way to soften the clash is to provide proper support to transition. The survey also reveals that the solution is not to choose between functional or processes, but to apply both in the organization, provided that there is space for negotiation and collaboration, in which managers can communicate and align the company's strategy with that of their area of operation and thus avoid the "approach of silos".

According to Neubauer (2009), a successful BPM project requires a well-organized team able to analyze, design, implement and continuously improve business processes according to the business strategy. Still according to the author, the following tasks must be performed by the main process manager - Chief Process Officer (CPO): creation and maintenance of business process models; consulting in business process management, integration of the major processes for the business strategy, definition of process targets, according to the process designer and process control.

Despite the importance of business process management, according to Neubauer (2009), Paim, Caulliraux and Cardoso (2008) and McCormack et al. (2009), the increased maturity level of BPM projects still occurs slowly. The maturity level will be the next topic that this article discusses.

Business Processes Management Maturity

Maturity models, according to Jeston and Nelis (2006), were designed to evaluate the competence, capacity and sophistication level of a selected area, thus becoming a tool that can help organizations to be more successful with BPM. Maturity models can be used for three purposes: (1) as a descriptive tool that allows an "as it is" evaluation of strengths and weaknesses of organizational processes; (2) as a regulatory tool that allows the development of an improvement guide; and (3) as a tool to allow a comparative measurement to evaluate the standards of other organizations.

The common basis for most maturity models has been the Capability Maturity Model (CMM), in which the maturity of the organization is evaluated through the five-point Likert scale, where "5" represents the highest maturity level.

Low maturity levels show companies with improvised or incorrectly performed processes, management focused on solving short-term problems, lack of measurement for assessing the quality of products or services, and little understanding of how process steps affect the quality of products or services. On the other hand, companies with high maturity levels are characterized by having organizational skills to define, implement and manage their processes, which are planned and documented. They are also characterized by having clearly defined roles and responsibilities, continuous updating of processes, support infrastructure to processes, quality control of products and services as well as of processes that produced them (OMG, 2008).

Neubauer (2009) analyzed the business process management in the market through research with 185 companies in order to assess the maturity level and how processes are managed. The results showed that only a small part of participating companies can be defined as process-oriented and that the vast majority of companies still have an orientation that includes end-to-end processes, measurement of results and business process management.

However, to efficiently implement BPM, specific tasks must be properly performed. For this, these tasks will be discussed below.

Process Management Tasks

Paim, Caulliraux and Cardoso (2008) identified a list of 24 tasks in the business management processes that have been classified by depth and importance, and thus grouped into three categories, generating a proposal that has been tested by a more thorough literature review and a questionnaire aimed to assess the importance of each task within the group and also identify the predominant type of management within the organization studied. These three task groups consider how the elements of organizational functions relate to the business management process, i.e., strategy, information and knowledge, innovation and improvement, information technology, people and skills, performance indicators, budget, standards and procedures, control and audit, work coordination and production systems.

In this paper, the development of the case-study in the surveyed companies, the three task

groups of the instrument developed, validated and tested by Paim, Caulliraux and Cardoso (2008) were used. The three task groups will be better shown and described in Table 1.

Table 1: Business process management tasks.

Task group	Description
Designing processes	Tasks including understanding the internal and external environments of the organization with respect to business strategy. This strategy includes objectives, goals and approaches to promote the change. Process teams must be formed and it is necessary to understand, select and prioritize processes. Thus, the following tasks are part of this group: understanding the external and internal environment, establishing the strategy and approach for change; ensuring the sponsorship for change, understanding, selecting, prioritizing processes and tools; forming teams of diagnosis and procedures; understanding and modeling processes in the current situation; defining and prioritizing solutions to current problems; defining management practices and implementation of processes; understanding and modeling processes in the future situation; defining and implementing changes in processes.
Managing day-to-day processes	Tasks including implementing processes and changes; promoting the performance of processes; monitoring and controlling the execution of processes; and accomplishing short-term changes.
Promoting development and learning	Tasks including recording the performance of processes; conducting the process benchmarking; recording and controlling impact deviations; evaluating the efficiency of processes, and recording the learning about the process. It is based on understanding the trajectory of process development through actions that increase the process predictability, understood as the best relation between promising or waiting for a performance and being able to deliver what was promised. This capacity basically depends on getting to know what the historical bases of performance are.

Jeston and Nelis (2006) claim that the leadership should recognize that there is no end in improving business processes; this is a program that must be continuously maintained. According to Antonucci et al. (2009), the measurement is important, but the measurement continuity, monitoring and controlling the process is even more important. To define what to measure, one must understand the desired results and observe the process as a whole in relation to customer satisfaction.

However, as previously mentioned, if on one hand, the migration from traditional management model to business process management results in dramatic improvements in process performance, on the other hand, it promotes an increase in management complexity, since firstly, the migration generates the need to coordinate and, secondly because the operations were able to expand their volume dramatically, becoming larger and more

complex. In this context, to migrate from the traditional model to business process management, companies will have to overcome barriers that certainly will be found in this changing process.

Barriers to the advancement of Business Process Management

The model of organizational structure based on functional management has limitations and appears to be restrictive to deal with this reality (PAIM, CAULLIRAUX AND CARDOSO, 2008). However, most organizations are managed at department level and still cannot perceive, in fact, the inter-relationships between organizational processes. In this sense, McCormack et al. (2009) reports that to develop the business process management, it is necessary to have an organizational structure that defines the process and roles of business processes management and breaks the old functional structure that inhibits the systemic vision of the organization.

Paim, Caulliraux and Cardoso (2008) highlight that the ready-to-use technology available in market is based on the current paradigm and not on the new one. In addition, the acquisition of new technologies represents a high cost. Another aspect highlighted is the unavailability of staff to operate these new technologies and according to the current model, managers tend to select IT solutions based on functions not on processes. According to Trkman (2010), the environment of an organization is an important variable in determining the IT investment level.

Trkman (2010) reports that companies must carefully align their business processes with the environment and ensure flexibility and continuous adaptation of their core processes. Therefore, they must determine that business processes are key processes to contribute to competitive advantage.

Sentanin, Santos and Jabbour (2008) conducted a BPM implementation study in a public research center that administered the challenges of progress along the stages and BPM levels and found that, considering the impossibility of a company to return to previous stages in its trajectory towards BPM, continuous improvement requires the participation of all members of the research center in a process where functional mentality must be broken and the view based on continuous processes has to be built. These are key conditions for overcoming the barriers to consolidating BPM.

One barrier to be highlighted is the organizational culture, since organizations long have privileged the functional coordination of work. In this case, according to Palmberg (2010), there is a big concern about people who rather take orders than assuming greater responsibilities.

Another difficulty to face is that the concept of processes is still little pervasive in organizations (TRKMAN, 2010).

Jeston and Nellis (2006) claim that often areas are working the same logical abstraction of the process, but with different names; the little integration between methodologies, techniques

and tools used in different areas; the different views of the set of activities, products, customers and other components of the process.

According to Antonucci et al (2009), the direct involvement of leadership and executive team, the process itself, incentives and rewards to encourage the adoption of new processes, the creation of cross-functional teams to participate and cooperate with the process, the development of continuous improvement, commitment to investment and alignment of the business strategy with the customer are key for the implementation of business process management. Bandara et al. (2007) point out that the lack of connection between strategy and BPM projects have been identified as one of the major flaws in business process management. Bandara, Gable and Rosemann (2005) in their study, identified stakeholder participation, information, expertise of the modeler, project management and support from top management for their success in modeling the business process. The need for involvement of top managers, the link between BPM and organizational strategies, the careful connection between IT and business strategy are critical success factors identified by Trkman (2010) in his study. In this context, communication, involvement of stakeholders, and support from senior management were critical successful factors for the implementation of BPM systems identified by Ravesteyn and Batenburg (2010). The authors suggest that large projects should not be developed without the support from a top-down approach.

Thus, the suggestion for the development of organizational learning is the participation in seminars, courses, presentation of case-studies and visits to companies that have implemented BPM, which involves not only the internal organization, but also customers, suppliers and partners.

SURVEY METHODOLOGY

This case-study was chosen because it is a qualitative construction of field research and represents the preferred strategy regarding issues like "how" and "why" (YIN, 2009). This case-study involves an intensive analysis of a relatively small number of situations. Yin (2009) adds that the case-study offers the richness of details obtained as advantage and as research effort, it contributes in a unique way for the understanding we have about the individual, organizational, social and political phenomena.

The criterion for selecting these companies was due to the fact that they are making major changes in their management model, for the decisions and actions that were relevant to the purpose of this work, and also due to the greater ease of access to respondents. Thus, the method used for the selection of cases in this study was the convenience sampling research.

In-depth interviews were made with the administrative director and manager of companies directly involved with the processes of organizations. For the development of the interviews, a questionnaire validated by Paim, Caulliraux and Cardoso (2008) was used, which identified and verified the importance of BPM tasks, and also identified the predominant management model in companies.

Thus, the interview guide used was structured in three blocks that corresponded to three task groups developed by Paim, Caulliraux and Cardoso (2008), which are: thinking, which refers to

the tasks of process design, acting, which relates to day-to-day process management, and learning, which corresponds to promoting the development and learning of processes, as shown in Table 5. Each task composing the groups above was evaluated in terms of importance for the studied company. The maturity level of companies in relation to the business process management and barriers found in implementing this management model were also identified.

Table 5: Task groups for the business process management and their variables.

Designing Processes (First group)
Understanding the external and internal environment
Establishing the strategy and approach for changes
Assuring the sponsorship for change
Understanding, selecting and prioritizing processes
Understanding, selecting and prioritizing tools
Forming teams for process diagnosis
Understanding and modeling processes in the current situation
Defining and prioritizing current issues
Defining and prioritizing solutions for current problems
Defining the management practices and implementation of processes
Understanding and modeling processes in the future situation
Defining the process changes
Implementing new processes
Managing day-to-day processes (Second group)
Implementing processes and changes
Promoting the performance of processes
Monitoring the implementation of processes
Controlling the performance of processes
Accomplishing short-term changes
Promoting development and learning (Third group)
Recording the process performance
Implementing process benchmarking
Recording and controlling impact deviations
Evaluating the process performance
Recording the learning about processes

Source: Authors are based on Paim, Caulliraux and Cardoso (2008).

PRESENTATION AND ANALYSIS OF CASES

The interviews were conducted in the first half of 2010. One of the companies surveyed is in operation for 40 years, and the other is a relatively young company that operates in the market for 7 years; however, both are reputable and well-known in the segment due to the quality level of their services. Another interesting aspect concerning the companies surveyed refers to changes in the way processes are managed; so it became possible to examine issues relating to the objectives of this study. The presentation and data analysis have been

summarized into four topics: description of companies, maturity level in business process management, importance of tasks in the business process management and key barriers.

Description of companies

The first company analyzed was called Company A, which is a provider of services in the advocacy segment that has branches located in important regions of Brazil. It was founded in 1969 and operates throughout Brazil, Mercosur, Mexico, United States and Europe in the following areas: Tax, Civil, Commercial and Corporate Law, Labor, Criminal, Administrative, Environmental and Biolaw, Cooperatives, Sports, and Paralegal Report and Control.
The second company surveyed was called Company B, which is a teaching and research institute in administration established in 2003 through the union of Administration teachers, researchers and professionals and currently has the support of about 200 teachers. It operates in three complementary areas: education, research and organization extension (consulting).

Maturity level in business process management

Based on literature review and in accordance with data obtained from the interviews, it could be inferred that Company A is at level two of maturity in relation to the set of tasks that are part of the process design, called acting by Paim Caulliraux and Cardoso (2008). According to Jeston and Nelis (2006), companies that are at level two of maturity have already had early experiences on BPM and with more people envisioning the organization from a process perspective, they begin to develop their BPM ability.

In the view of the interviewed manager, the concern for the customer is very intense in the mission and its values. He believes that: "*If I want to meet my client's needs and I have to stay alert all the time to what he is expecting: from the reception when he enters the company up to financial accountability. I have to involve internal staff to be aware of this and prepare our day-to-day activities to achieve this goa*l".

In relation to day-to-day activities involved with BPM, which compose the second task group, company A is at level one. At this early stage, according Jeston and Nelis (2006), companies make some unstructured and uncoordinated attempts of BPM. This becomes evident when the manager says that these activities are developed in isolation and alone, with no defined and transverse processes. For some activities, the interviewee believes that the best way to develop them is by business department.

The third group of activities related to promoting development and learning are still not developed by Company A that, therefore, is rated within category NA (not applicable). This is due to the fact that this company is at the beginning of the BPM implementation, i.e., it is still developing tasks from the first and second task groups.

On the other hand, in Company B, the seeking for certification as required by its customers made it develop faster in relation to company A in its business process management. The company hired a consulting firm that assisted in obtaining certification in all areas simultaneously, which also contributed to the implementation of the business process

management. Therefore, Company B is at level four of maturity in tasks from the first group - designing processes. According to Jeston and Nelis (2006), companies that have achieved this level begin to enjoy the benefits of having BPM strongly rooted to their strategy.

There was also a great evolution of Company B in relation to day-to-day process management, which, according to the interviewee, was achieved at the expense of much debate. Currently, activities are implemented in order to improve the production chain as a whole. An important fact to be highlighted is the need of the figure of a leader that monitors the process indicators and assists the implementation of processes so that no task is misaligned. At some point of the BPM implementation, this figure was not clear for the other team members and there was no monitoring of the BPM implementation and evaluation of processes, generating loss of efficiency in the implementation of the new management model. According to Antonucci et al. (2009), no use pointing out the mistakes, detecting failures and have no control. That was already highlighted by Company B.

In relation to the accomplishment of short-term changes, company B points out that not making these changes will affect the future of the organization, which happened in the functional management model.

Regarding the performance of processes, Company B is at the phase of readjustment of process indicators that need to be reviewed periodically, because those who do not help in any major decisions making are discarded. Company B makes use of benchmarking by means of the consulting firm that passes information on the best practices. Another factor highlighted is that only two companies in Brazil else than the researched company are certified.

Thus, with regard to the task group "promoting development and learning" Company B is at level three, because it has indicators that are being reassessed, obtains information on the improvement of processes by the consulting firm, but does record formal learning. It does not use reports or systems to generate information about rights and wrongs in relation to processes.

Importance of tasks for the BPM

Respondents were asked to rate each BPM activity contained in each of the three task groups according to their degrees of importance.

Company A rated most activities related to designing processes (first group) as extremely important. The manager said that the analysis of the environment is very important for designing the processes and establishing the change strategy and approach is part of the goals established by senior management.

Except for the activity of accomplishing short-term changes, which is considered by the manager of Company B as very important, all others from the group managing day-to-day processes (second group) were considered of utmost importance. Regarding the tasks of promoting development and learning (third group), since they are activities not yet

implemented in the company, for being at the beginning of the BPM implementation phase, they were classified as indifferent.

In relation to tasks from the group "designing processes", Company B considers most of the tasks very important. The emphasis was given to the analysis of internal and external environment, which was essential to define the migration of the management model. The organization came to be viewed as a whole and when deciding whether to certify only the teaching area or all areas of the company, the managers decided to make change in all areas, and since one area depends on the other, the lack of quality and process standardization in the research may undermine the teaching area.

Another task that deserves mention is the understanding, selection and prioritization of tools. According to Company B, this task is considered indifferent, since they consider tools important, but they are not priority. The company implemented the new management model only with the available tools.
Forming teams of diagnosis is extremely important for Company B, who needs to watch its steps and know how far it can get. The prioritization of solutions to current problems is of great importance, but they are taking too long to find the cause, perhaps due to the lack of knowledge on the interrelationship of all the processes involved by some people.

In relation to the second task group – day-to-day BPM, Company B considers the implementation of processes and changes irrelevant because it has already implemented all the processes, but stressed the great importance of monitoring the implementation of processes.

Regarding the group of promoting development and learning, Company B considers the tasks of great importance and was willing to develop them even though it is starting this phase, as previously it was focused on the tasks from previous groups.

Main barriers

Company A is fully aware of the benefits arising from the BPM and therefore has expended considerable effort to move forward in this management, in the attempt of overcoming the barriers found.

The main barriers found by Company A are: lack of methodology, involvement and perceptions of those involved in relation to BPM, large number of members with different perceptions, diverse profile of clients, cultural change, specific characteristics of the company's areas and lack of commitment from senior management, which have been identified in some studies as key success factors for BPM (BANDARA; GABLE; ROSEMANN, 2005).

The barriers faced by Company A are the result of a family-run model, which is fully departmentalized, operating for 40 years, with most staff working in the company for many years (on average 7 years, managers and partners - 20 years in the company). The difficulty in implementing any change in processes is very high due to an old pattern of corporate thinking.

The main barriers faced by Company B are: changing organizational culture, lack of consensus among people, lack of setting goals in common, lack of planning, proper job descriptions, understanding of problems and investment, and lack of knowledge on the need of recording learning as identified as success factors in some studies by Bandara, Gable and Rosemann (2005), Bandara et al. (2007), and Trkman (2010).

Company B has overcome some barriers by the help of a hired consulting firm, and thus developed training, made formal and informal meetings as an incentive to involve the staff and to overcome barriers as suggested by Antonucci et al. (2009).

Note that the main barrier found refers to the organizational culture, or to the departmental thinking of people, and the main barriers were faced during tasks from the first and second groups due to their impact on the organization.

CONCLUSION

Based on literature and field research, it could be concluded that companies recognize the importance of business process management, but their development levels are still relatively limited. With regard to the maturity level, it was observed that BPM is a complex practice for companies.

The BPM tasks emerged in response to increased competition between companies that have pursued their certifications, leading them to turn their attention to BPM. The tasks identified relate to project designing, day-to-day management and learning.

The migration from one management model to another, or from one paradigm to another, may be slow because the process of new practices may be restricted by various barriers. Since the overall objective was to assess the maturity level of companies in relation to BPM and the main barriers found for the migration of the management model, it could be concluded that companies are committed in implementing a management model focused on processes because they understand the importance of this management model to improve the quality of their services.

By analyzing activities related to BPM in general, it is possible to conclude that Company A is at level two of maturity as previously explained. The intention of obtaining the ISO certification has helped Company A to advance in business process management.

In general, Company B is at level four of maturity due to tasks already implemented. It could be inferred that this company is at higher maturity level due to the following factors that differentiate it from Company B: being a young company focused on research, the CEO's view about the importance of BPM and the hiring of a specialized consulting firm.

It should be observed that due to specific characteristics of the companies surveyed, they followed different lines of thought regarding the BPM implementation. While Company A considered it more appropriate to start implementing BPM in a gradual way, since the change in the management model in the company as a whole could generate a great impact on its

culture, Company B, in turn, decided to implement BPM in the company as a whole, since it clearly sees the transverse processes.

With regard to the importance of the tasks for companies, it could be concluded that in general, tasks are very important, despite the different maturity levels between the companies surveyed. Company B considers much more important the task group related to learning than Company A, in which this task group still does not apply due to the fact that this company is at the beginning of the management model change process and they will be important when it reaches a higher BPM maturity level.

There are barriers related to people and to business segment. The barriers faced by the companies surveyed are somewhat similar with regard to people, organizational culture and others features that are specific to each market segment, such as the diversity of the Company A's customers and the number of employees who have been working a long time in the company. On the other hand, Company B has already faced a financial barrier, not identified in company A.

One of the limitations of this study concerns the fact that this study is based on an extensive bibliographic database as opposed to a limited capacity of empirical validation.

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C4 – Organizational-management perspectives

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DESIGN PROCESS AS A PART OF NEW PRODUCT DEVELOPMENT – CASE FURNITURE INDUSTRY

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ABSTRACT

Time-based competition, first-mover advantages and a fast product development cycle time are some of the strategies used in order to gain competitive advantage in the current fast-changing competition environment. New product development (NPD) is one of the key components when implementing these strategies. Design process lies in the core of NPD, especially in the furniture industry. This paper aims at depicting the design process and the prerequisites to it being both fast as well as successful. The design process is seen as an interaction process between the designer, the entrepreneur and prototype makers. The process depiction and other results are also compared to some main NPD processes suggested in the reference literature. Three kinds of new products and related NPD processes are discussed: high tech products, low tech products with large innovations and low tech products with small innovations. This paper is based on empirical qualitative research conducted by observing and interviewing several designers and entrepreneurs in the Finnish furniture industry during the autumn of 2010. Some interesting observations have been made. It seems that the designer and the entrepreneur often see the design process in a different way: the designer feels that he should get a good picture of the company, its goals and strategies as well as current products before starting the design work whereas the entrepreneur expects the designer to create something new, more 'out of nowhere'. This may result in products that do not suite the company thus wasting precious time.

Keywords: New Product Development (NPD), design process, furniture industry

INTRODUCTION

Delivering a product to a customer rapidly can bring a company clear competitive advantage and the furniture industry makes no exception to this (Tammela, Canen and Helo 2008). Good quality and a low price are taken more and more for granted and this turns the focus to time (Wilding and Newton 1996). However, it is not only the actual delivery of a product to a customer being fast that can bring competitive advantage to a company but, also, bringing new products to the market quickly is important. A company developing products faster than its competitors may benefit by getting higher prices, more loyal customers, and a greater market share (Langerak and Hultink 2005). Time-based competition, first-mover advantages and fast product development cycle time are some strategies and tools for gaining these advantages.

The concept of time-based competition (also called time-based performance) was introduced by Stalk in the late 1980s. In this strategy, time is seen as a resource that should not be wasted any more than any other resource. The idea of time-based competition is to reduce the cumulative lead time of a product and thus gain competitive advantage. The cumulative lead time includes various processes throughout the organisations, e.g. new product development (NPD), production, procurement, sales, and transportation. (See e.g. Tammela et al. 2008; Vickery, Dröge, Yeomans and Markland 1995.) Research in first-mover advantage or pioneering advantage shows that the first company to enter a new market often gains larger market share than companies coming to the market later. It has been noted that this applies to different situations: consumer and industrial markets as well as growing and saturated markets. (Kardes, Kalyanaram, Chandrashekaran and Dornoff 1993; Michael, 2003.) 'Fast product development cycle time', 'rapid product development', and 'new product development speed' are all terms that refer to attempts to speed up the product development process in order to gain competitive advantage. These concepts mean generally how fast a company can turn an idea into a product in the market place. (Chen, Damanpour and Reilly 2010; Gupta and Souder 1998.)

Vickery et al. (1995) have been investigating time-based competition in the furniture industry. Historically this industry has often been connected to long delivery times. However, competition has also forced companies in this business to try to find ways of attracting more customers. Vickery et al. (1995) discovered that the product development cycle time was the sole predictor for market share in comparison to the new product introduction time, production lead time and delivery speed.

In industries like the furniture industry design lies in the core of the new product development process. There are various definitions for 'design' in the literature. Keeping the furniture industry in mind, this paper uses the definitions of Walsh, Roy and Bruce (1988): "[design is] *the configuration of elements, materials and components that give a product its particular attributes of function, appearance, durability, safety and so on*" and Ulrich and Pearson (1998): "*product design is the activity that transforms a set of product requirements into a specification of the geometry and material properties of an artifact*". Gupta et al. (1998) state that effective design is important to companies for various reasons. First, even though the cost of design may only be less than 10% of the whole costs of the NPD process, the decisions made in this phase determine as much as 80% of the total NPD costs. Secondly, making changes at this point is much cheaper than making changes during the actual production. Furthermore, customer satisfaction often depends on how well the product is designed.

This paper focuses on the design process part of new product development in the furniture industry. The objective is to depict the design process and the prerequisites to it being both fast as well as successful. Successful in this case means that the product should meet the end customers' needs, suite the manufacturing company's strategy and be effective to produce by the company. This paper is built as follows: theoretical background of new product development in general and some new product development models are introduced in the next chapter. This is followed by the introduction of the empirical research as well as its results. At the end of the paper the findings are discussed in comparison with the theory introduced earlier.

THEORETICAL BACKGROUND

New product development

Product development has to be done within all industries. However, the nature of the industry (high tech vs. low tech) and the amount of innovation (incremental improvement vs. radical improvement) affects the product development process a great deal (see Figure 1.). Electronics and computers are examples of high tech industries whereas the furniture industry represents low tech industries. Banbury and Mitchell (1995) define incremental innovation as "*refinements and extensions of established designs*". Compared to incremental innovations, radical innovations aim at bringing about something totally new either from a technological or some other point of view (Verganti 2006). While product development in high tech industries concentrates on technological innovations and following the rapid changes in technologies (Datar, Jordan, Kekre, Rajiv and Srinivasan 1996) the strategies in low tech industries have to be different. Typically in the furniture industry the main emphasis is on shapes, materials and ergonomics and sometimes, as Verganti (2008) presents, radical innovations are searched for in meanings.

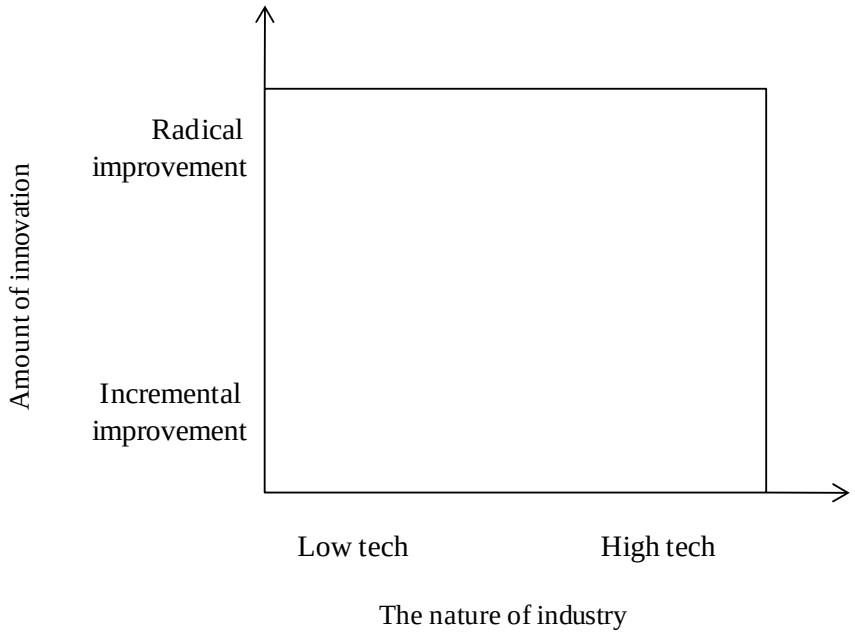

Figure 1: Different cases of product development.

Fast product development cycle or time to market is considered an important source of competitive advantage especially in industries in which product life cycles may be even less than two years (Datar et al. 1996) but also in various other industries (see e.g. Vickery et al. 1995). Chen et al. (2009) list a number of antecedents that have an effect on new product development speed. These antecedents are goal clarity, process concurrency, iteration, team leadership, team experience, team dedication and internal integration. Menon, Chowdhury and Lukas (2002: 324) on the other hand emphasise the learning perspective: "*change, flexibility, dynamism, cooperation, invention, innovation and information*

utilisation should be embraced" in order to gain rapid product development.

Product development models

Generic product development process

Ulrich and Eppinger (1995) have introduced a five-phase product development process model (see Figure 2) that has influenced both academic discussion and practices in companies. The model provides tasks for each phase and also the responsibilities of the different functions of the organisation in different phases. A product development process is defined as "*the sequence of steps or activities that an enterprise employs to conceive, design, and commercialise a product*" (Ulrich et al. 1995: 14).

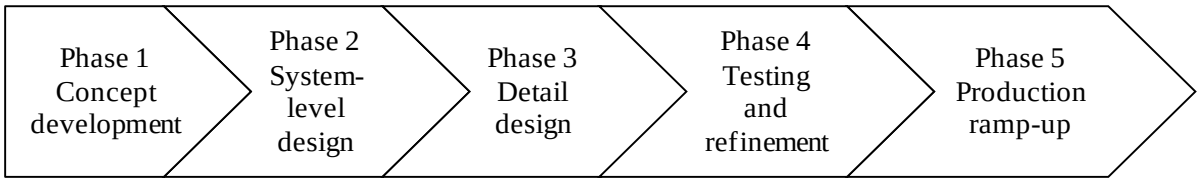

Figure 2: Product development process (Ulrich et al. 1995: 9).

In phase 1 "Concept development" new product ideas are created based on the needs of the target market. A number of concepts are then created based on these ideas. Finally, one concept is selected for further development. A concept does not only include description of the product but also deals with market potential, competition and economical issues. In the second phase "System-level design" the product is broken down into smaller subsystems and components. Strong emphasis is also on the actual production or assembly process. (Ulrich et al. 1995.)

The next phase "Detail design" takes the process even deeper. All the unique parts of the product are defined in detail: specifications of geometry, materials and tolerances are prepared. Standard parts to be purchased are identified and detailed plans for parts to be manufactured are made. In phase 4 "Testing and refinement" the product is tested from various points of view. Alpha prototypes are intended for making sure that the design works and satisfies the customer. The objective of beta prototypes is to assure that the performance and reliability of the final product is sufficient. (Ulrich et al. 1995.)

The final phase "Production ramp-up" aims at preparing for the actual production. The production process is refined and workers are trained. At some point the ramp-up phase turns into full production and the product is launched to customers. (Ulrich et al. 1995.)

Stage-gate model

The stage-gate model seems to be the most common product development model used by companies. According to Cooper and Edgett (Cooper and Edgett 2005: 133) about 54 % of businesses use it properly with well defined stages, gates and activities but the number of companies that have some sort of stage-gate model in use is even higher. The stage-gate

model is based on years of academic research with a large number of new product development projects. The first versions of the model were introduced in the beginning of the 1980s and since then it has been further developed to suit different companies and various situations. (Stage-Gate® is a registered trademark of the Product Development Institute Inc.) (Cooper et al 2005.)

The stage-gate model can be considered both a philosophy as well as an operation model for product development. The main idea is to turn product development into a well-structured process with clear and well-defined stages (to go through certain activities) and gates (to make a go/kill decisions). At each gate a project may be terminated. The model consists of six stages and five gates (see Figure 3). (Cooper et al. 2005.)

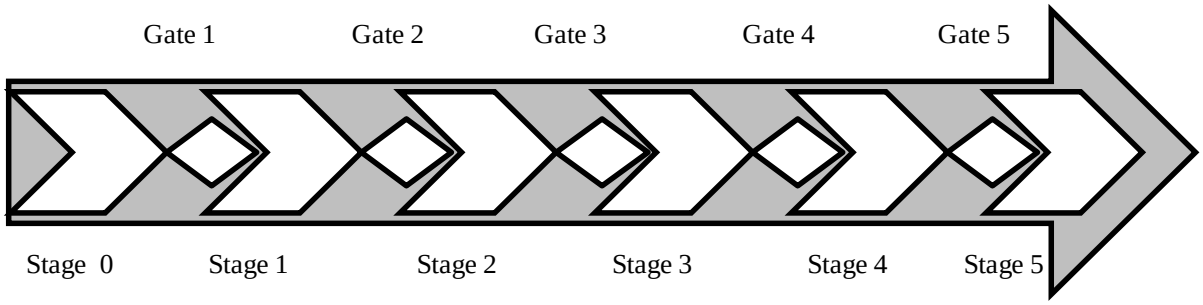

Figure 3: Stage-gate model (modified from Cooper et al. 2005: 140).

The stage 0 “Discovery” is for creating/finding opportunities and new product ideas. Based on the decision at gate 1 only some ideas will continue further. The stage 1 “Scoping” means preliminary research that will quickly provide information about the opportunity/product idea which will help make the decision at gate 2. In stage 2 “Build the Business Case” further investigation is done and this leads to product definition, project justification and a project plan. This investigation is carried out on both market as well as technical aspects. This stage is again followed by a gate that will determinate some of the projects. Stage 3 titled “Development” deals with the actual design and development of the product (or even service). Some testing should also be included in this stage. If the product still has potential enough it will pass gate 4 and continue to stage 4 titled “Testing and Validation”. And finally, after gate 5 only some products go on to stage 5, “Launch”. (Cooper et al. 2005.)

It is important to note that also the stage-gate model is a general model in the sense that it does not provide detailed answers to companies using it. The model gives hints for what to do and ask at each stage but the companies themselves have to modify the model to fit their own business. However, this forces the companies to actually define their new product development process which may lead to improvement.

A number of other new product development models can also be found in the literature. For example Peters, Rooney, Rogerson, McQuarter, Spring and Dale (1999) introduce a new product design and development model that includes three parts: pre-design/development, design and development process and post-design development. These parts are divided into six phases: idea, concept, design, pre-production validation, production/distribution and post-company. This model is different to the two models presented before in the sense that

it links post-design development stronger into product development but otherwise the product development process is fairly similar.

EMPIRICAL RESEARCH

The research presented in this paper is part of a project called Experimental Design Lab, "EDEL". The main purpose of EDEL is to create and test new ways of working for the Finnish furniture industry. One way of achieving this is to bring professional designers and manufacturing companies to work together stronger than before.

This paper is based on qualitative research conducted by observing and interviewing several designers and entrepreneurs in the Finnish furniture industry during autumn 2010. A total of 8 designers were given a task to design a piece of new furniture based on a brief. Three of the designers have industrial designer qualifications and the rest are interior architects. The briefs used are as follows: a social kitchen as the heart of the home, a bedroom for senior citizens and a home office.

The designers spent about four weeks in a small village in Western Finland (in periods of 1 to 2 weeks at the time) so the researcher had a possibility to observe their work and discuss with them several times. Observations were also made when the designers met with the representatives of local furniture companies and interacted with joiners. All the designers were also interviewed. A semi-structured interview was used so that the designers would have the possibility to freely describe the design process as well as their work. The themes used in the interviews included:

- ☐ the road through which the person became a designer
- ☐ the design process (e.g. starting the process, inspiration, co-operation and interaction with the furniture company)
- ☐ ideal way of working vs. reality

In addition to the designers the researcher also discussed with several representatives of furniture companies. The objective was to illustrate the new product development processes used in the companies.

RESULTS

A process chart of the actual design process was drawn based on the discussions with the designers (see Figure 4). The design process is, in this case, limited to the part of the product development process the designer is mainly responsible for. This is the part of product development in which the appearance, materials as well as function(s) of a piece of furniture are decided. Although each designer has a unique approach to design work, the design process itself seems to often be fairly similar.

The process begins with creating ideas. Normally a designer has a brief from the customer, e.g. to design a new dining table for the current line of products or to design a piece of furniture for senior citizens. It is not easy for a designer to point out the source of the idea in a particular case. Designers seem to "collect inspiration" wherever they go and whatever

they do and then use this “collection” when they design something. Ideas may come from the nature, professional or other magazines, buildings, people, interesting shapes or colours or just about anything.

There are a great number of issues to be considered when a designer is planning a new piece of furniture. One group of issues is related to the use of the furniture: the planned use or multiple ways of using the furniture, the user, non-planned use, and the space in which the furniture might be used. Another group of considerations is related to the furniture itself: shapes, colours, material, and ergonomics are all examples of these issues. Designers also have to consider the production of the furniture: how will it actually be manufactured. The structure and different parts of the furniture are important from this point of view.

Sometimes creating ideas involves gathering information. The designer may not possess enough knowledge about e.g. the users or the materials. They may discuss with the representatives of the user group or read some studies about the non-familiar issue. However, the designers say, without this work a good result cannot be reached.

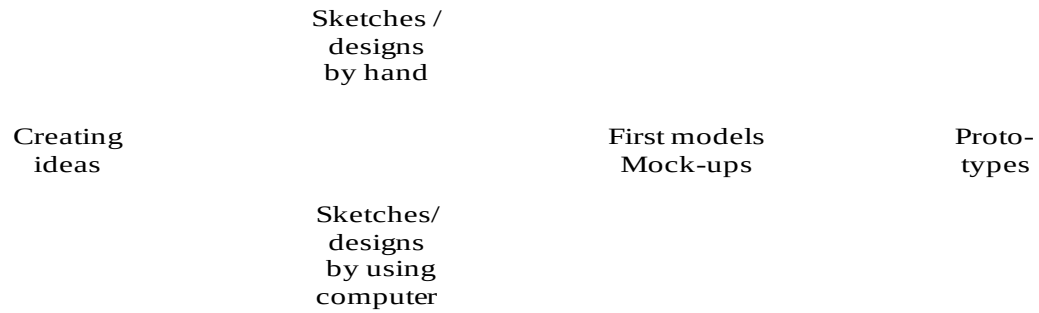

Figure 4: The design process.

The next phase of the design process is to prepare sketches and designs either by hand or by using some computer software. For some designers sketching and creating ideas are one activity and some designers think about the idea first for so long that it is almost ready when they actually begin to draw it. Sometimes a designer makes sketches first by hand and only after that uses the computer to prepare final designs. Moving back and forth between creating ideas and making sketches and designs seems to be typical for the design process.

Concrete, three dimensional models or mock-ups are built in the next phase of the process. The designers say that it is sometimes difficult, even for them, to perceive for example the proportions of the finished piece of furniture without actually seeing it and therefore mock-ups can be built. Sometimes a designer wants to see how the material can be used and models are built for that purpose. Shape, too, can be the reason to build a model and in this case it can be built also of other materials or in another size than the actual furniture. Based on the experience of the models the designer may go back to the previous phase and

redesign some parts or the whole piece of furniture.

In the final phase a prototype or more is built. The purpose of the prototype is to show what the piece of furniture will look like when produced in the actual size and of the actual material that has been designed. Building a prototype also gives viewpoints for planning the actual manufacturing process. In this phase the designer may need help from someone who builds the prototype – either the customer company or an external party.

There are two important things to be noticed about the design process of furniture: 1) it is not a linear process, and 2) the designer should not be left alone with the process. The process does not often move on from one phase to another linearly. It goes back and forth between the phases and sometimes different phases can be carried out simultaneously. This makes it difficult to see how the process is actually proceeding.

Even though the designer is responsible for the process, she should not be left alone with it. Strong input from the furniture manufacturing company is needed throughout the process. Designers say that it is important for them to understand the company, its history, strategy and needs. That way they can design something that suits the company. It is also important for the designers to know what the company can produce from a technological point of view. Sometimes there is crucial knowledge about the materials and manufacturing techniques in the company that should be included in the design process. Therefore the design process should be a continuous interaction process between the designer and the company which will make it possible for new product development to be both fast as well as successful.

During the discussions with the designers a special case of new furniture development came up: designing totally new, innovative products. All the interviewed designers agreed that this should not/cannot be carried out by the designer alone; instead there should be a cross-professional team. For example if the objective is to create innovations in the field of furniture for senior citizens, the team might consist of an expert in geriatrics, technological expert(s), representatives of the user group and manufacturing companies in addition to the designer.

DISCUSSION

The purpose of the design process presented in this paper is not to replace the product development processes introduced earlier. Instead this paper aims at opening up the product development process from the designers' point of view to the manufacturing company and its management. Good design can bring a competitive advantage to a furniture company and in order to gain this advantage, co-operation is needed. Involvement of both the company and the designer is needed in successful new product development process which is highlighted also by Peters et al. (1999). And the more radical innovations are pursued, the more important it is to have a multi-skilled team.

Another objective of this paper is to complement the earlier product development models from the furniture industry's point of view. The main challenge in combining the design

process as the designers have presented it with the earlier product development processes lies in the fact that these product development models are strongly linear: when one phase is finished, you should move to the next and no longer return to previous phases. However, the design process of a piece of furniture is more iterative. Good solutions are searched by a trial and error method. Creating ideas and concepts, designing models and building prototypes are mixed together until the solution is found.

Is this because most product development models have their origin in high tech industries and furniture industry is a low tech industry? Or can the reasons be found in the differences of incremental and radical innovations? Perhaps neither of these explains the situation. It is likely that the earlier product development processes have a strong managerial view. And from this viewpoint the important matter is decision-making. The manager might not be so interested in the actual design process (that is hidden somewhere in the phases or stages) but in the results that can be used when deciding whether to continue the process or not. This could also be the viewpoint of a large company where the management might not be so involved in the actual design work. However, it seems that for the manager of a small furniture company the only way to survive might be getting interested and involved in the design process, too.

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DEVELOPING ORGANIZATIONS' INTERNAL COMMUNICATION BY COMMUNICATION AUDITS

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ABSTRACT

Organizational communication is critical for any organization to function well. By the means of communication, knowledge is transferred and shared in organizations. In addition, communication is an enabler for organizational learning. It is important to continuously invest in developing organizational communication. Communication audits provide means to gain information of the current state of and to enhance organizational communication. This paper discusses what kind of methods should be used for a communication audit to enhance organizational communication. Prior literature presents several processes and methods for communication audits. Both quantitative and qualitative methods have been used. The purpose of this paper is to understand what kind of process and methods are suitable for ICT circumstances.

The paper starts by literature review concerning communication audits. Advantages and disadvantages of different methods are argued. Then, the paper presents a communication audit method used by the author. This method was used in five product development project cases to understand the current state of organizational communication and to enhance communication in each case. Based on the findings of this paper, organizations can choose methods suitable for their purposes to conduct a communication audit and to enhance organizational communication.

Keywords: Communication, communication audit, internal communication, communication audit methods

INTRODUCTION

Organizational communication has been interest of researchers already decades. It has been noticed by both academics and practitioners that communication is critical for any organizational to function well. Communication provides means for knowledge creation, transfer and share, and thus enhancing organizational learning.

There has been enthusiastic interested towards assessing the current state of communication and based on assessment, generating development actions communication to better functioning. Organizational communication audits are means to provide management information concerning organizational communication and its effectiveness. Communication audits are used for exploring, examining, monitoring, and evaluating communication. Audits are used to reveal gaps in the communication process and to provide suggestions for improvements (Henderson, 2005).

Communication audit provides new information of the organization. Typically audits consider communication as a process related to other organizational processes (Downs & Adrian, 2004). For example, an audit may reveal weaknesses in human resource management related issues like feedback from management on one's contributions in one's job. As a consequence of an audit, enhancements may be gained, in addition to communication process, in many organizational processes. The results of organizational communication assessment – how the personnel view the organization, management and strategic goals – can also be used to benefit strategic planning of the organization (Hargie & Tourish, 2009).

In addition to that communication assessments benefit communication practices, an audit itself can be considered as a communication method (Downs & Adrian, 2004): to conduct a communication audit gives an impression that management is interested in perceptions of the personnel. For those participating in the auditing process, it also provides an opportunity of influencing one's own work. The participants involved in the planning and follow-up phases of the auditing process are provided with a comprehensive approach to the whole communication process.

Essentially, communication audits emphasize the viewpoint of personnel involved in the communication processes to be audited. An audit gives management verified information on how personnel perceive communication and related processes. Instead of relying on rumors or grapevine a communication audit substantiates and checks the accuracy of personnel perceptions. It gives feedback to the management on how the communication process is perceived to be working (Zwijze-Koning & de Jong, 2007).

Multiple methods have been used in communication audits. Previous literature has shown the advantages of both quantitative (Clampitt, 2000) and qualitative (Dickson, 2000; Millar & Gallagher, 2000; Dickson, 2009) methods. The most often used include interviews, surveys, focus groups, observations, network analyses, content analyses, communication diaries, and critical incident analyses. Typically, different methods are used to complement each other (Hargie & Tourish, 2009).

Zwije-Koning and de Jong (2005) argue that, among the organizational communication audit literature, there is a lack of discussion of what kind of information can be sought through different methods used in communication audits. They state that triangulation is important but not sufficient requirement when selecting methods used in an audit. In addition, although it may be that the research process and selected methods need to be case specific, the suitability of each method for collecting the needed data (regarding the purpose of the research) has to be considered.

Only rarely the studies argue what methods are suitable under which circumstances, and what should be considered when selecting the methods to be used. Methods affect the type of data gained, which further affects what kind of conclusions can be made and what kind of results can be expected from the audit process. In addition, there may be organization-specific constrains related to data gathering methods: for example, do the personnel have their own computers in use (then e.g. internet-based questionnaire is suitable option) or not (then e.g. surveys need to be made by paper form).

The aim of this paper is to discuss *what kind of research process is suitable to study (intra-project) communication effectiveness in high technology product development organizations?* In the following chapter examples of the typical methods used are placed and their advantages and disadvantages are discussed. Then, the paper presents a communication audit process and discusses the strengths and limitations related to the proposed process.

METHODS TO STUDY ORGANIZATIONAL COMMUNICATION EFFECTIVENESS

Communication audit process may involve different kind of methods. It is typical that the audit process includes a survey. By surveys auditors are able to collect quantitative data of the communication in the organization.

Surveys are very popular methods used in communication audits. The most popular surveys are Communiaction Satisfaction Questionnaire (CSQ by Downs & Hazen, 1977), ICA Audit Survey (Goldhaber & Krivonos 1977, Goldhaber 2002), and LTT audit questionnaire (Wiio & Helsila 1974, Wiio 1977). These may also be accommodated into case-specific circumstances. These surveys have slightly interest towards communication process and the themes covered are slightly different (Table 1).

Table 1: Themes covered in communication audit surveys.

Survey	CSQ	ICA Audit Survey	LTT
Themes covered	Communication climate	Amount of information received versus amount of desired (various topics)	Overall communication satisfaction
	Relationships with supervisors	Amount of information sent versus amount of desired (various topics)	Amount of information received from different sources (current state vs. ideal)
	Organizational integration	Amount of information received versus amount of desired (various sources)	Amount of information received about certain job items (current state vs. ideal)
	Media quality	Amount of information received versus amount of desired (various channels)	Areas of communication that need improvements
	Horizontal (informal) communication	Amount of follow-up versus amount of desired	Job satisfaction
	Organizational perspective	Timeliness of information	Availability of computer information systems
	Relationships with subordinates	Organizational relationships	Availability of computer information systems
	Personal feedback	Satisfaction with organizational outcomes	Respondent's general communication behavior
			Organization-specific communication
			Information-seeking patterns

Surveys presented in Table 1 have been validated meaning that the tool measures the things it is supposed to measure. However, from the table it shows that the contents of the surveys differ as well as the viewpoint they take to what is considered to be important. Based on the themes covered by the surveys as presented in the table, it can be concluded that these most popular surveys all have slightly different viewpoint to communication process and to what is considered important. CSQ includes communication climate and related aspects like organizational integration, informal horizontal communication. In addition, there is a strong emphasis on superior-subordinate communication. On the other hand, ICA audit survey highlights receiving and sending information. LTT survey has special attention into information seeking and computer information systems. The themes covered by the survey are, of course, related to each others. However, it can be concluded that in a communication audit, if a survey is used, its contents can be planned case-specifically depending on the current interests.

Communication Satisfaction Questionnaire (CSQ) is a quantitative tool providing statistical data about employees' communication satisfaction (Zwije-Koning and de Jong, 2007). CSQ is a method to analyze respondents' satisfaction with ten dimensions of communication system (Zwije-Koning and de Jong, 2007). CSQ has been used e.g. in a research by Zwije-Koning and de Jong (2009) where each item was measured on a scale from 1 to 7, and mean scores for each item and confidence intervals for each dimension were calculated.

There are also other surveys used to audit organizational communication. For the basis of the research process developed in this paper and presented in following chapters, two other surveys were analyzed. These include a survey by Müller (2003) and COMPASS survey by Construction Industry Institute (1996) (compare the context from Appendix 1). The survey by Müller concentrates on information management viewpoints. The COMPASS has a wider outlook. The strengths of the COMPASS include that it is in electronic form: the respondents can fill in an electronic form to answer the questionnaire.

Hargie & Dickson (2007) studied organizational information flows in four organizations using Episodic Communication Channels in Organization (ECCO) questionnaire. ECCO questionnaire was developed to measure personnel's knowledge of in-house policies regarding to informal and formal grievance policies. The questionnaire was sent altogether to 832 disproportionatedly selected persons.

The advantages of using the ECCO questionnaire include providing exact information of employee knowledge level. ECCO questionnaire can also be implemented in variety of contexts and purposes. Shortcomings of using ECCO include that it is time consuming. In addition, there is a risk that the questionnaire is seen as a test of employees rather than a feedback channel. Additionally, the tool provides only quantitative data and lacks of respondents' explanations or interpretations of the causes. (Hargie & Dickson, 2007). The critics towards ECCO questionnaire include also that it does not made any difference of the role of the respondents: people working in different roles or organizational units may perceive information flows differently.

Besides survey, also other methods to collect and analyze data can be used in communication audits. Critical Incident Technique (CIT) and Network analysis are among the

most popular ones. CIT is a qualitative tool studying any communicative incident towards that the employees have positive or negative feelings (Zwije-Koning and de Jong, 2007). Critical incident technique investigates personnel communication experience (Hunt et al. 2000).

Critical incident technique (CIT) has been used e.g. by Hunt et al. (2000) in a study of communication experiences by education managers. In this study interviewees were asked to (regarding communication) document three critical incidents that occurred during their working. The interviewees were also asked to document the main strengths and weaknesses of communication within the organization. Based on the gathered data, a content analysis was made to identify respondents perceptions of communication processes, main patterns of communication incidents and current communication climate in the workplace.

Network analysis can be used to reveal communication structure within the organization. The data can be used to detect information blockages and to generate new communication structures. (Zwije-Koning and de Jong, 2009)

More than one method in the audit process

It is typical that the audit process includes more than one method to collect and analyze data. For example, CSQ has been used in different kind of audit processes to supplement data gathered by e.g. interviews, critical incident technique, and network analysis.

Zwije-Koning and de Jong (2007) present a study where they analyze the reliability and validity of Communication Satisfaction Questionnaire (CSQ) by comparing it to Critical Incident Technique (CIT). Special attention was paid to that does the CSQ covered the themes found to be important based on the CIT analysis. In addition, they analyzed whether both of these tools can be used by the researchers to explain employees overall communication satisfaction and do these two different types of tools point to same directions of communication satisfaction or dissatisfaction.

Zwije-Koning and de Jong (2007) found out that the CSQ is a suitable tool for generating an overall view of how the employees perceive organizational communication. However, they argue that CSQ is not so suitable for identifying specific challenges related to communication or, for generating proposals of how to develop communication.

In another study, Zwije-Koning and de Jong (2009) in their communication audit among three large high schools from Netherlands utilized network analysis, the critical incident technique, and the CSQ. All data was gathered in interviews from 45 minutes to two hours. For the network analysis they asked personnel to identify with whom they interacted the most, about which topics (the topics were categorized into coordination, strategic issues, and personal ones), and how often. After that, a social network analysis program UCINET (Borgatti et al 2002), was used to calculate network analyses.

In their research, Zwije-Koning and de Jong (2009) utilized different types of methods for organizational communication audit. Each method provided different type information and

thus supported making analysis and conclusions of the shortcomings of communication within the studied organizations. For example, in interviewees stated that decisions were made without their involvement which was supported by that 21% critical incidents pointed at decision making and that network analyses showed strongly centralized decision making networks.

In her research, Vos (2009) introduces a different type of an instrument to study communication quality and added value in municipalities. The instrument is based on balanced scorecard by Kaplan and Norton and quality control procedures that the European Foundation of Quality Management (EFQM) utilizes. The used instrument covers interviews of communication professionals and general managers. The interviewees were asked to name indicators of communication quality and examples of good or bad communication regarding corporate communication, policy communication and, organization-related communication. In addition, the auditors searched for facts and figures to support the findings made from interviews. The process ended with a seminar with relevant stakeholders to discuss the outcomes of the research process.

Vos (2009) reports that the validity of the instrument could be improved by using external auditors and by providing more facts and figures to support the findings from the interviews. She also reports that the seminars promoted creating a common understanding and improvement plans. Vos (2009) argues that this kind of research enhances dialogue between communication professionals and top managers, and that after the research the top managers better understood the effects of communication.

SPECIFIC NEEDS FOR THE METHOD IN ICT CIRCUMSTANCES

In this chapter a discussion is presented concerning what to consider when generating a communication audit for ICT product development.

In ICT companies, the speed of product development is crucial. Thus these companies invest in efficiency and effectiveness of product development operations. For example, there are continuous investments in increased speed of new product introductions (Mallick & Schroeder, 2005) after the product development is essentially the life-blood of an ICT company (Campbell & Holmes, 2004).

Organizing product development in ICT companies has some special features that shape communication systems of these organizations. For example, ICT product development projects typically involve a network of companies and subcontractors (van Echtelt et al. 2008). In such projects, engineering personnel need to interact both with the employees by his/her own company and with the employees of the other companies involved in the cooperation. Thus, personnel need to be aware of agreed practices related to communication over organizational boundaries. It is not only the managers but also the engineering personnel who have the responsibility to put efforts of effective inter-organizational communication.

ICT product development is complex from the viewpoint of communication. The personnel in product development projects are typically geographically distributed i.e. multi-site

(Paasivaara 2005). Even though the project may not be multi-site, there are often many national cultures involved (multi-cultural, Harvey & Griffith, 2007). Additionally, there are several on-going projects in the product development, and the personnel maybe involved in several projects at the same time (Killen et al., 2007). In ICT projects the product itself is complex (complex product structure, Birk & Heller 2007) and may involve professionals with different backgrounds: e.g. software designers, electronics designers, mechanics designers, system designers (multi-technical projects) (Edmonson & Nembhard, 2009). These aspects should be considered when planning a communication audit.

Communication in ICT product development projects is enhanced typically with the newest communication technologies. Computer-aided communication is present in everyday interaction in these projects. In the case that a communication audit studies the current situation of the communication system in the organization, the audit should also recognize the position of all these technologies used in the organization. The auditor may also use this as an advantage: if the personnel are familiar to use different communication media, why not to use those as data collection tools in the audit.

An important constrain for conducting a communication audit in ICT product development is that time is critical in ICT business: the auditor is expected to use as little time of the persons involved as possible for conducting the audit. When possible, the auditor should acknowledge this when planning the auditing process.

DESCRIPTION OF THE DEVELOPED PROCESS

The process developed to study (intra-project) communication effectiveness in high technology product development organizations is presented in this chapter. The process was developed based on the literature review of communication audits.

As recommended by the earlier literature, multiple data collection methods were decided to be used. The methods (Figure 1) were selected in order to them to provide both quantitative and qualitative data of the phenomenon under study. In addition, it was considered important that the methods would cover not only the viewpoint of management but also employees working in the project. The aim was to provide rich data of the phenomenon. At the same time the aim was to use as little time as possible of the people participating to the research. An important intention was to, during the research, check from the empiric whether the methods needed some revisions (i.e. did the planned research process and methods correspond enough to the reality matters). Following steps were selected to the research process:

- initiation (getting started with the research in the company)
- thematic semi-structured interviews;
- documentation by the organizations;
- a web-based survey;
- focus group work;
- analysis and interpretation.

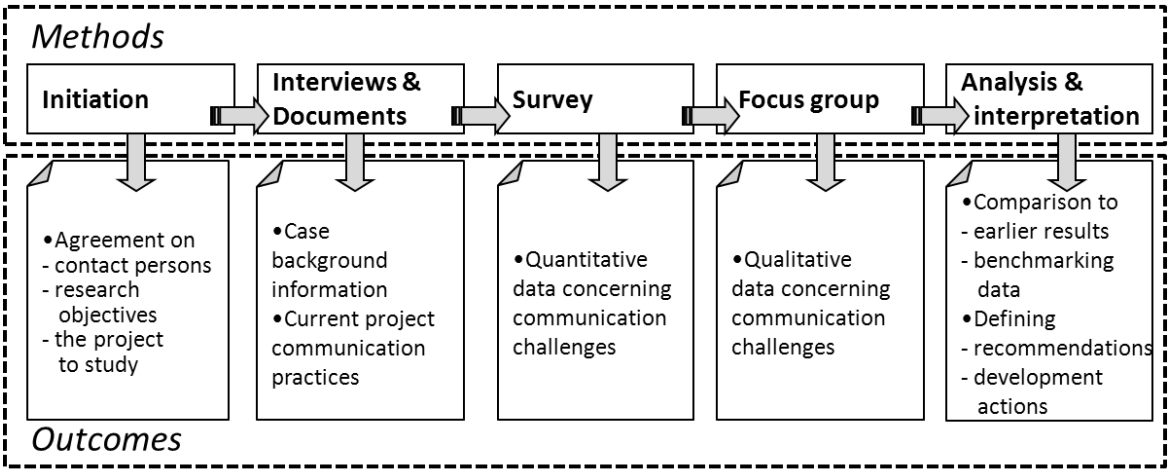

Figure 1. Methods and related outcomes.

The purpose of the *Initiation* phase was to get started with the research in the company as smoothly as possible. The second step, *thematic semi-structured interviews* were used to provide qualitative data from the personnel interviewed. Next step, *documentation by the organizations* would provide mainly qualitative data (it is possible that this phase includes also quantitative data) that is objective and represents the organizations' official guidelines. This phase is expected to either provide different information than the interviews, or to support findings from the interviews. The third step, a web-based survey, was used to provide quantitative data for the auditing process. *Focus group working* was included in the auditing process to enhance dialog within the organization to be audited as well as between the auditor and the organization. The last step in the auditing process is *Analysis and interpretation*. This phase was decided to include as it would provide an opportunity for a wider viewpoint to the phenomenon: the results of current auditing could be compared to e.g. earlier results. In the following, the rationale and realization of each step is explained in more detail.

Initiation

Using an external auditor brings it important to have some kind of initiation phase before starting the research. Suring this phase a common understanding between the auditor and the audited party should be gained about what is going to be done and what to expect from the process. This should include discussion about the purposes and goals for the process: what outcomes each party may expect to come about and how the outcomes will be documented and shared. There should also be a common understanding of the exact methods used e.g. the contents and the structure, what each method is expected to reveal, and how much time will their utilization require. In addition, the roles and responsibilities of the parties involved should be made clear, as well as the contact information and frequencies. For example, it is good to document who has the responsibility to define and provide contact information of the participants to the following research phases. Also other possibly case-specific roles are to be discussed and agreed.

Interviews & documents

The main data gathering methods in the research process documented here are the survey and the focus groups. To support these, interviews and studying certain organizational documents are conducted beforehand. The objectives of the interviews are the following:

- to familiarize the auditor with essential current project communication practices in the case. Based on this information the auditor can check whether all relevant aspects of communication system within this specific organization are covered in the survey.
- to familiarize the auditor with the current communication follow-up practices and earlier development actions related to project communication in the organizations. This information can be used as a reference data of earlier surveys within the company.
- to document background information of the studied projects. This kind of information is important to documents especially if the data gained during this audit is used as a benchmarking data.

The first two objectives are supplemented by studying organization specific internal documentation. The documentation may include such as guides for conducting a project plan, or earlier survey reports. Organizational documents provide information about the official communication system within the organization and may reveal e.g. essential communication processes, the main media used, and utilized data bases.

Survey

Communication audits typically include a survey. To develop the survey for this research process, the strengths and weaknesses of other similar-like typically used surveys were analyzed. This analysis was used as a starting point to a survey questionnaire to be developed. From this analysis it shows that in addition to consider the contents of the survey, one has to make certain decisions on technical realization of it. At first, the selection of paper or electronic forms brings further choices to consider: how much do we set limits for the time and place for the respondents to give their answers. These considerations affect the internal and external validity of the audit. External validity i.e. the generalizability of the results is weakened by low response rate. Thus, we may want to make giving responses as easy as possible by e.g. sending an email with an internet address where the respondent can give his/her reply. On the other hand, being able to give answers whenever and wherever suitable to the respondents lessens the auditors control over the process, and possibly lessens the internal validity (i.e. real existence of the professed causal relationships). For example, how can we be sure that the responses given are truly given by the person we expected?

Considering these aspects the survey was decided to be conducted using a web-based questionnaire. Utilizing internet applications enables more flexibility to the audit process: the respondents may give their answers whenever it is suitable for them. In addition, it lessens the paper work related to the audit, and provides the data in an electronic and easily handled form.

A web-based questionnaire requires a technical solution i.e. a platform where the questionnaire runs. To avoid the development efforts of a technical platform, a web-based questionnaire provider was chosen (ZEF Solutions Ltd.). There are several advantages for using the tool. Firstly, the questionnaire was easy to develop due to user-friendly user-interface of the tool provider. This allowed time savings in the audit process as a total. In addition, the tool was perceived as user-friendly for the respondents, which was important in order to the response rate to be as high as possible. Also, during the initiation phase the company representatives emphasized the importance of the ease of the audit process for the respondents. With the selected tool the respondents were easy to reach (email). Additionally, the tool provided data in a form that was easy to analyze.

Contents of the communication audit questionnaires differ. In this audit process, the purpose of the survey is to reveal how satisfied project personnel are with different communication aspects present in product development. The questionnaire was developed utilizing earlier research of communication audits, especially CSQ (Downs & Hazen 1977), ICA Audit Survey (Goldhaber & Krivonos 1977, Goldhaber 2002), and LTT audit questionnaire (Wiio & Helsila 1974, Wiio 1977). In addition, research done by Müller (2003) and the Construction Industry Institute (1996) was used. The questionnaire was then modified based on the information found during the interviews and documents review. In this modification phase certain questions were added in order to the contents of the questionnaire better cover the realities of high technology product development projects. The contents of the survey are presented in Appendix 1.

The purpose of the survey was to reveal how satisfied the personnel are to project communication and how much support individuals get from their superiors or from the organization. Thus, the questionnaire covered perceived satisfaction of horizontal (team, other project members, members of other projects, subcontractors, customer) and vertical (superior, briefings) communication, and typical communication media in the organization. In addition, the questionnaire explored perceived satisfaction of communication about roles and responsibilities, personal feedback, lessons learned and change management. The items gathered for the questionnaire were divided into eight modules (see Appendix 1).

The draft of the questionnaire was refined based on the discussions and findings from the interviews. The final questionnaire form included altogether 66 questions. However, because the case projects had somewhat different communication media in use, the number of questions for each case organization varied: of the 66 questions 60 concerned case A, 50 case B, 51 case C, 50 case D, and 52 concerned case E (see details in Appendix 1).

The final questionnaire had three kinds of questions:

- questions with multiple choices the respondent could choose from;
- questions with Visual Analogue Scale (VAS) (Metsämuuronen 2001);
- three open-ended questions at the end of the questionnaire.

When answering the multiple choice questions each respondent could only pick up one option. The VAS questions allowed answers to be given on a continuous scale. VAS questions have been used especially in measuring the status of health and quality of life (De Boer et al. 2004). Most of the VAS questions used in the survey had two dimensions:

importance and satisfaction (or importance and frequency). For example, if the question was about "communication planning", the respondent would give his/her answer at the same time to questions "How important is communication planning?", and "How satisfied are you with communication planning in your project?" (see Fig. 2). Thus, the respondents gave their answers to both dimensions at the same time.

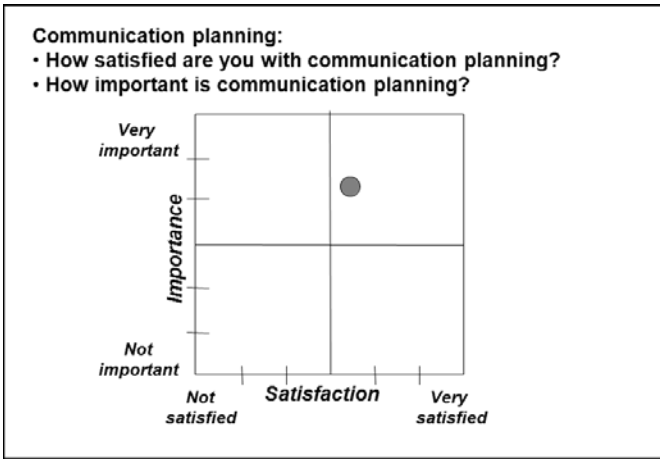

Figure 2. An example of a VAS-scaled question with two dimensions.

The extreme positions for the VAS questions were:

- Importance: Very important – Not important;
- Satisfaction: Very satisfied – Not satisfied;
- Frequency: Frequently enough – Not frequently enough.

Focus group

The rationale for the focus groups was to complement the audit by providing qualitative data about the strengths and weaknesses of the communication within the organization.

Focus group method is a group interview where a group of people are gathered to discuss a specified topic (Wilkinson, 2004). The essential information is the contents of the discussions during the working. Thus, focus groups are a way to collect qualitative data. Advantages of focus groups include that, compared to e.g. individual interviews, focus group method allows communication concerning the topics (Krueger & Casey, 2000): during a focus group session the participants can discuss their viewpoints, ideas and perceptions about the theme given. Focus group method is expected to enrich the understanding of strengths and weaknesses found based on the survey. Audits are done to check the current situation and to propose some development actions. Focus groups may point out possible constrains related to planned development actions originating from organizations realities. Additionally, focus groups provide a possibility for arguments for and against of the coming changes. This will enhance building commitment to the new direction of operations.

An important phase in using focus group method is the design of the group composition. Or the discussion to be fruitful, there should be suitable number people with relevant background. A survey could well cover large number of people, but for a focus group from 6 to 8 persons is typical (Morgan 1998). In this audit process it was considered important that

a wide understanding of the personnel perceptions was gained. Thus, the focus group participants would represent different roles from the project: designers and other engineering personnel, supporting functions (e.g. quality support for the projects), and project management.

Focus groups should have a predefined agenda including topics or themes to be discussed. In this case, the agenda of the focus groups were defined to include two main steps:

1. identification of project communication related topics that focus group participants considered requiring improvement actions the most;
2. generation of ideas on how to develop each topic named in the first part of the focus group working.

The interest in the working of the focus groups was manifold. From the phase one it would be interesting to note whether focus group participants would choose the same topics that were highlighted in the survey results, and if not, why. It is possible that certain weaknesses are because of practical constrains of the organization, and thus cannot be really sorted of. From the phase two, new ideas on how to develop project communication would emerge. This information can be utilized in organizational development projects.

The described process was applied in a research of project communication among five high technology companies (Väänänen 2010). The process included data collection from five cases. Thus, a cross-case analysis was conducted and provided for the cases participated as a benchmarking data.

Analysis and interpretation

In this phase the data collected during the earlier phases was analyzed and compared to each other. This was found to be important after the data from different phases, to some extent, pointed to different communication challenges. After the audit process was completed, it was clear that it was useful to include all these different data gathering methods as they truly provided more information for the auditor.

In addition, in this phase the data collected could be compared to the results of possible earlier audits, or, if available, other analyses done within the same industry. This kind of benchmarking analysis was included into this phase.

CONCLUSIONS

Organizational communication has been an interest for academics and practitioners for decade. Efficient communication is essential for effective management of any organization. It is essential to continuously invest in communication development. Communication audits are means to gain information of the current state of and to enhance organizational communication.

Earlier literature presents different methods used in communication audits. The selection of methods may include both quantitative and qualitative methods. An auditor needs to

consider which methods are suitable in each audit process. This paper aims to present a process to be used in ICT product development projects' communication audits.

The paper suggests that, in order to gain comprehensive understanding of the current situation, a communication audit in the studied context should include multiple data gathering and data analysis methods. Still, the process should require time from the personnel involved as little as possible.

This paper presents a process used for communication audit in ICT product development projects to include six phases: initiation (getting started with the research in the company), thematic semi-structured interviews, documentation by the organizations, a web-based survey, focus group work, analysis and interpretation.

Data collection methods were divided into four steps. The first one includes thematic semi-structured interviews that were used to provide qualitative data from the personnel interviewed. Next step, documentation by the organizations was included to provide mainly qualitative data that is objective and represents the organizations' official guidelines. The document supported findings from the interviews. The third step, a web-based survey, was used to provide quantitative data for the auditing process. The fourth step was focus group working and its purpose was to enhance dialog within the organization to be audited as well as between the auditor and the organization.

Data analysis was conducted after each data collection step to provide information for the next data collection step. In addition, after the four data collection steps, an analysis and interpretation phase was included to compare all data to each other and to provide comparison to possible earlier audits within in the company or in other companies (benchmarking analysis).

Communication audits should be conducted regularly. The aim is to provide information on where possible problems are developing before serious problems arise. If conducted regularly, communication assessments also provide information on how the organization is progressing in relation to communication (Downs & Adrian 2004).

The limitation of this paper include that the communication audit process presented in this paper was applied in five cases in ICT sector companies. Interesting themes for future research include applying the presented process in different companies operating in ICT or other industries.

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Appendix 1. Survey questionnaire questions.

Module[1]	Question	2D[2]	Reference: Downs & Hazen (1977)	COMPASS	Müller (2003)	Wiio (1977, 1974)	Interviews
A	1. In which site is your workplace located?			x			x
	2. Organization you belong to			x			x
B	1. What is your role in this program?		x		x		
	2. What is your role in this project?		x		x	x	
	3. How well do you know the top five formal objectives of your program?		x	x	x	x	x
	4. How well do you know the top five formal objectives of your project?		x	x	x	x	x
	5. Success of the program			x		x	x
	6. Success of the project			x		x	x
	7. Communicating with persons from other programs		x			x	
	8. Communicating with persons from other projects		x			x	
C	1. Program communication in general	x	x	x		x	
	2. Project communication in general	x	x	x		x	
	3. Communication plan: Is there a communication plan in the project/program?						x
	4. Communication planning	x					x
	5. Understanding what is expected from you	x	x			x	
	6. Understanding roles and responsibilities	x	x			x	
	7. Introduction to communication methods and tools	x	x	x		x	
	8. Knowing where or from who to get information you need		x	x		x	
	9. Access to people with information necessary to you		x	x		x	
	10. Access to information necessary to you		x	x		x	
	11. Being kept up-to-date with changes	x		x		x	
D	1. How well do you understand how your project affects other projects?						x
	2. Communication with other projects	x					x
	3. How well do you understand how your program affects other programs?						x
	4. Communication with other programs	x					x
	5. Project/program customer: How well do you know the project/program customer?		x				x
	6. Communication with the project/program customer	x	x				x
	7. Communication with external project personnel		x				x
	8. Communication problems: at what level do you think communication problems mainly occur?			x		x	
E	1. Project follow-up: How important are visual control practices like schedule at white board?				x		x
	2. Document management system	x	x	x	x	x	
	3. Program intranet pages	x		x	x	x	
	4. Project intranet pages	x		x	x	x	
	5. Info email / Project newsletter	x		x	x	x	
	6. Project reviews	x		x	x	x	
	7. Project meetings	x	x	x	x	x	
	8. Project team meetings	x	x	x	x	x	
	9. Program info sessions	x		x	x	x	
	10. Project info sessions	x		x	x	x	
	11. Communication by email	x	x	x	x		
	12. Communication by phone	x	x	x	x		
	13. Primary information source			x	x		x
F	1. Your experience in project work					x	
	2. Communication inside the project team	x	x			x	
	3. Communication between teams	x	x			x	
	4. Communication between the team and the project manager	x	x			x	
	5. Communication between the team and the program manager	x				x	
	6. Team spirit in the team	x				x	
	7. Team building	x				x	
	8. Knowing how the job affects the project success	x	x			x	
	9. Knowing how the project affects the overall business	x	x			x	
	10. Open and honest communication	x				x	
	11. Managing with conflicts					x	
	12. Considering your reporting to project management		x			x	
G	1. Working hours allocated to this project						x
	2. Informal and ad-hoc meetings	x	x			x	
	3. Training of personal communication skills	x				x	
	4. Receiving feedback on contributions to the project	x	x			x	
	5. Meeting the project manager	x	x			x	
	6. Meeting the program manager	x	x			x	
	7. Communication lessons learned						x
	8. Receiving conflicting instructions		x	x		x	
H	1. Current good practices in project communication?					x	
	2. What communication practices should be avoided?					x	

[1] Modules: A General questions 1, B General questions 2, C Communication in your program, D Communication with project & program stakeholders, E Information management, F Leadership 1, G Leadership 2, H Improving communication.

[2] 2D: the question had two dimensions: satisfaction & importance or satisfaction & frequency.

3. How could communication be improved?	x	x
4. Your age		x

EXPANSION OF RESEARCH AND DEVELOPMENT BRINGING FRESH INNOVATION AND RELEASING INTERNAL RESOURCES

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ABSTRACT

Product development is one of the most valuable tools to help a company survive in the market field. Competition is getting more and more brutal every year and only those who can change their business habits and products quickly enough can survive to make profit in the long-term. Rapidly changing markets force companies to research and use the newest possible technologies. Due to the rapid evolution of products, customers are demanding more and more all the time. Besides the demands of the technical improvements, customers are starting to take into account the impact their purchases have on the environment which is starting to become more of a driving force in their decisions. Holt (2002) said that the key for success in the business is developing new products and improving old products.

The product development process is very long and includes countless decisions. One wrong choice can lead the whole project failing. Ulrich (2000) has found that more than 50% of all R&D projects will fail totally and only a select few actually create something new and revolutionary. Companies which use their R&D skills to compete in their market field have to decide what their best strategy is. Trott (2008) has defined the four different product development strategies; First to market, follower, imitator & lower of the costs and satisfier of special segments.

In the "First to market" strategy, companies have to make sure that they are the first to offer a new technology or application to customers. This strategy includes lots of risks and demands a high knowledge of the newest technologies. The "Follower" strategy also demands a high level of acknowledge so that the company can produce cheaper and superior versions of the rival product which are already in the market. "Imitator and lower of the costs" strategies are normally the most difficult strategy to maintain for a long period of time. The main idea is to manufacture and sell products very cheaply to attain profits through a larger volume. In Trott's final strategy, "satisfier" of special segment" the company concentrates on filling the gaps in the markets which the rivals have left open. The case company of this research is partly focused on this strategy.

In this research we have used Ulrich's theory called the "Expansion of Research and Development" in our case company to help their own overloaded R&D team. To help the adaptation of the new R&D process, we undertook interviews and filled out questionnaires in the case companies own R&D team to find out their thoughts and attitudes about the outsourcing of R&D. The results of the interviews from the case company's own experts shaped the final form of this study.

Keywords: R&D, Outsourcing, networking

BACKGROUND

Researchers have long known the importance of product development on a company's future. Outsourcing is now one of the hottest subjects in the business world and still divides opinion. Even though most of the newest studies support outsourcing, it is surrounded by lots of doubts and fears which slow down the growth of the outsourcing trend. Burkholder (2006) has listed the most common myths and doubts around outsourcing; there is a high risk involved in outsourcing critical parts of the business, the costs of outsourcing are higher than the costs of reducing the number of your own employees or the motivation of the employees of the supplier or not as high as it would have been in an internal team.

None of these claims are true. In a lot of cases the company has already outsourced critical parts of its business, for example the car industry started to outsource the manufacture of motors a long time ago and a reliable motor is a very important part of the company's image. The costs of outsourcing are actually much lower than the employees trying to reduce costs and an outsourcing company will gain access to new tools and technology from the supplier without any extra investment. The motivation of the supplier's employees is often higher because the company and the supplier both have same goal; satisfied the customer. In a relationship between two companies, conflicts are much more uncommon than in an internal organization.

The outsourcing of product development is a pretty new idea but many global companies have already done it for a long time now in low cost countries. In Finland the trend of R&D outsourcing was raised very quickly before the latest depression. In the best case scenarios some engineering and design companies' turnover and number of employees grew by 30% in just one year.

Outsourcing used to be more important for big companies whose market area and products were focused on low level technology. Now outsourcing is also used in high level technology companies. They are aware of the fact that in the current economic climate no company can rely solely on their own R&D teams. Outsourcing also refreshes the company's organization and rules. Internal R&D teams have to concentrate more on standards and provide documents so that the supplier can understand the wishes and demands of the client. Superior documents will also serve the company much better in the future.

Outsourcing can also save money, despite experts saying that if the only reason to outsource is to cut losses the attempt will fail. Tidd and Trewhella (1997) say that sometimes outsourcing is a faster and more efficient way to get results than building the necessary and missing skills within the internal organization. Companies will gain most from outsourcing when their goals are to gain access to new technologies, tools or expertise. Outsourcing will release the internal team to focus on their core competence and the whole company will benefit as a result.

TRADITIONAL R&D

Basically all research and development processes obey the same fundamental structure. Cagan (2001) summed up the three main steps; product planning, plan approval and product launch. The time in-between steps one and two is divided into identifying, understanding, and carrying out the new ideas. After approval the time will come to refine the product, manufacture the prototype and begin preparations for product launch. According to Cagan(2001), if a company obeys these steps it will be able to reduce the number of potential development problems.

The case company in this research is a high technology company which has a very efficient and strong internal R&D team. The company runs a huge amount of R&D projects every year and they have formed very strict protocols and rules on how to handle all the new ideas. The case company's own gate model is well prepared and it is easy for them to coordinate and control a lot of projects at the same time. The main idea of the gate model is that before the project continues to the next step, it has to pass the previous gates demands. This model takes a lot of time and human resources because every gate means meetings and tasks for the people who are participating. The progress of the projects is slower and more expensive. All the ideas and points of view are coming from within the same company.

Interviews during this research revealed that the employees thought that no-one knows everything. It is common sense that the person who knows most should be in charge.

EXPANSION OF R&D

According to Cagan (2001) and Vogel (2001) a company needs to be successful at using the appropriate R&D tools, a good plan and a team which works well together using the correct methods. To find and use these correct methods requires a lot of resources. Research and development is not only for one internal department but for the whole company. Every company should underline the importance of R&D to its whole staff, because in many cases the best initial idea comes from production where employees are in contact with the real products on a daily basis.

Ulrich's (2001) idea is to expand R&D not only to other internal departments of the company but also to suppliers. Below we have diagram of Ulrich's theory. This figure has been the frame theory and point of view for this research.

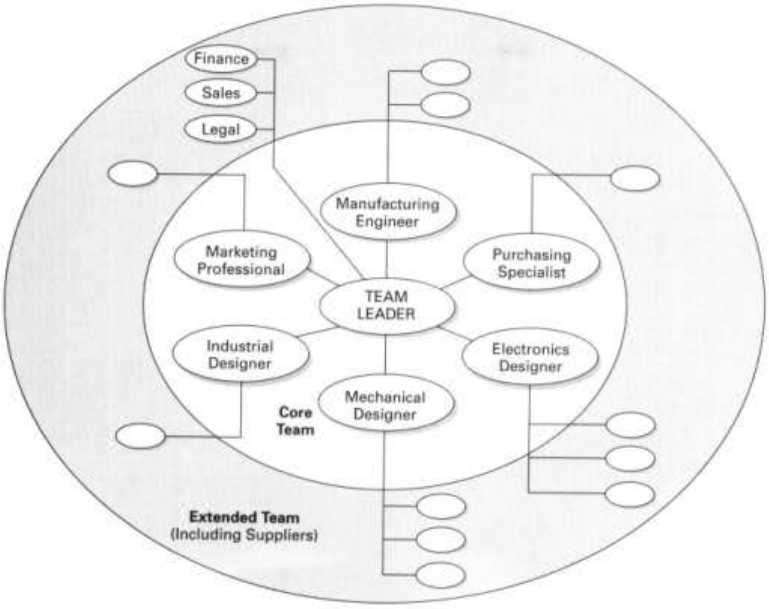

Figure 1: Ulrich theory of expanding R&D process.

CASE STUDY

The main target for this research was to find a new R&D methodology for our case company. The case company's internal R&D team was heavily overloaded and stressed and the company was oblivious to the fact that this kind of situation could cause serious damage to the capability of whole internal team. Champion (2002) stated that if the R&D team can focus without stress on one project at a time, the results will be remarkably higher and employees would be less likely to suffer from burn out.

The case company was highly committed to their own gate model so we arranged interviews in different departments within the company and a wide scale questionnaire for the whole internal R&D team. The aim was to find out their doubts, opinions and attitudes for and against the outsourcing of the R&D project. We collected a lot of information from inside the company and used that to represent our idea of outsourcing one certain product's development project.

The beginning of the project was good and the results started to show after only a few weeks work. The supplier who was selected to complete this project did an excellent job and the case company's old product got a new structure and small face lift. After the prototype was manufactured we arranged a questionnaire for the supplier about the behavior of the case company. Even though the case company was a client and could potentially provide an excellent opportunity for the future, the supplier was not afraid to give words of advice. Most of the feedback was very positive and showed that supplier was very content with the case company and for the opportunity it got due to this research.

CASE STUDY RESULTS

This research was successful, because in the beginning both sides decided that if the prototype was ready on time, the project would pass. The other goal was to cut manufacturing costs by 25-30%. The supplier believed that and it probably would have managed to reach these savings but the case company wanted to play more safely. In the middle of the project they denied some of the suppliers' ideas. If the prototype one day became a volume product, manufacturing costs would drop by about 10-15 %, so we could say that this goal was achieved. The main target of this project was of course to see how the outsourcing of R&D fitted into the case company's organization. The questionnaires show that outsourcing is possible when the transition toward it is slow enough. The supplier gave the outside party its opinion of the behavior and actions of the case company. All the information we collected during this study is very valuable for the case company's management in the future. It will help them to make decisions concerning outsourcing in general and especially in the research and product development fields.

VALIDITY, OBJECTIVITY AND RELIABILITY

We selected the supplier by evaluating the skills of their R&D department by having interviews and by implementing a small design task. Besides interviews and tasks we checked the products that they were manufacturing at that moment. After these checks we found that choosing the supplier was very easy.

The case method for this research was theory of expanding research and development by Karl Ulrich. Ulrich's theory is widely accepted and used also in a few other case studies. There are also other theories such as Trott's product development strategies, which have been used for this research that have been recently published by well-known groups of theorists. Interviews from this research have been made in several different departments and only one person at a time. These features will increase the objectivity of the answers because everyone will be able to state their individual point of view on the case.

Each person interviewed in the case company had more than 10 years of experience from same business field. 75% of employees from the internal R&D team who answered the questionnaire had more than 5 years of experience within the case company. The past experience of these interviewees increased the reliability of the data which was collected for this research. We also arranged questionnaires for the supplier and all five people who answered had at least 8 or years experience within the company. The supplier company also has almost 10 years of experience offering wide-ranging outsourcing services to global companies. This should make the feedback from the supplier in this case study more reliable.

DISCUSSION

The case company was looking for solution to its overloaded internal R&D team in an economical period when it was almost forbidden to hire new employees. The internal R&D

team was very stressed and the management of the company knew that if they didn't do something results and especially innovation would start to collapse. We used this research and Ulrich's theory of expanding R&D to help alleviate some of these problems for the case company. Of course this case study didn't solve the whole problem, but it worked as a first step. This research helped the internal team to see new possibilities for their situation. Employees got extra energy when they noticed that someone is interested in their job and that energy removed some of the stress from whole team.

Overall the case study was a success and will make it easier for the company to outsource in the future if they see fit. The internal team will probably always be the main driving force for development within the case company and maintain the responsibility of all R&D projects, but after this case study it will be easier for them to remove non-core competence tasks to someone else.

It was vital for the success of this research to find a reliable and skillful supplier. Choosing a supplier from the case company's own network sped up the project because the relationship between the case company and supplier had already been established.

FURTHER STUDIES

This research provides excellent opportunities for further studies. Results of this research allow further studies to focus on both the practical and also the theoretical point of view. From a practical point of view it would be good to observe the full life cycle of the prototype and answer several questions. Does it survive the rest of the tests that the supplier did not run? Will it ever be a volume product? What new ideas did this prototype give to its product families and How did the internal R&D team cash in on new innovations of the prototype?

Theoretical study could be used in this research as a starting point to business intelligence research. Business intelligence is quite a new term and will be studied more and more in the future. According to Laitala (2003) business intelligence means all kinds of critical information, which has been collected from every possible source. The managers of the case company will be able to use this valuable information in the future when making important decisions. This research includes a lot of business intelligence and it would be very easy to collect more information about the other segments of the business from both the supplier and the case company.

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REQUIREMENTS ON METHODS FOR MODERN PRODUCT DESIGN- MASTERING THE BALANCING ACT BETWEEN STANDARDIZATION AND CUSTOMIZATION

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ABSTRACT

The industrial revolution having taken place in Central Europe and the US during the 19th century significantly altered production methods as a result of newly developed technologies such as power engines. The consequence of available power machines was an increasingly standardized production process allowing for unprecedented cost-efficiency decisively contributing to thrive and prosper. Once wealth was established however, people's taste continuously rendered sophisticated and customer orientation gained in importance. The major objective of this article hereby is to investigate the correlation of the conflicting factors of economic success, namely customer satisfaction and cost-efficiency, and identify the crucial parameters behind them. This is accomplished by a three-step approach starting out from the manifold requirements business-level strategies imply. In a second step corresponding product design regimes are incorporated and analyzed for differences and commonalities in the third step. The result is that the various product designs may in fact all be explained by the same control factors, each appearing in alternating intensities of course. The obtained findings contribute to a 'catalogue of requirements' prescribing the essential criteria for an integrated product design methodology in the future.

Keywords: Modularity, Product Platform, System-level Design, Product Architecture

INTRODUCTION

No doubt – the common pursuit for economies of scale driven by the paradigm of capitalism appearing at the terminating 19th, beginning 20th century essentially contributed to the evolution of the western industry countries as well as the involved wealth and advancement. Thereby the simple parabolic logic 'the more you produce of something, the less costly manufacture is going to end up' respectively put in today's wording 'the more standardized components are, the cheaper you will be able to offer your products', dramatically influenced production processes and significantly changed the body of thought at that time. Not later than Henry Ford presented the idea of the moving production line coupled with his famous announcement of "one can have any color car as long as it is black", a new era was heralded - an era of previously unaffordable luxury and conveniences such as traveling, mobility and efficiency to be mentioning only a few.

As a downside of the above mentioned industrial and mechanized production operations however, a progressive displacement of the traditional craft-based businesses (which is one

skilled laborer occupying substantial control) became evident. Since benefits from specialized assembly and "task-partitioning" were not confined to car industries only, as a matter of course, followers of economies-of-scale principles continuously expanded to other areas of life as well. Hence previously tailor-made consumer and even commodity goods were subjected to standardization and price competition, with the single positive side-effect of ever decreasing sales prices for consumers (price-based strategy).

Yet initially described, economic status remarkably advanced during the course of the 20th century just as people's taste rendered sophisticated - once wealth is established. This became apparent in man suddenly desiring another color car than Ford's plain black beside a broad range of other more or less unique features to satisfy his personal preferences. As a consequence state-of-the-art offerings and involved standardized design paradigms lead to an increasingly unsatisfied buyership – preferably in the consumer good business areas. Hence producers needed to enter a business strategy rethinking in order to keep up with previously experienced successes and first of all not to be squeezed out of the marketplace. A trend displaying a more careful customer orientation in the products was becoming apparent. Thus, the strategic development in industrial production partly headed backwards to its roots which were originally lying in handcraft manufacturing and thereby fully customized goods. So, the solely goal no longer is to pricewise outperform the closest competitors, instead of rather carefully differentiate one's products towards customer desires in the respective market segment [10].

However, one major question remaining is how to best realize sufficient customer satisfaction and therewith organizational revenues without running the risk of producing a multitude of similar products and its often involved economic downsides such as high production costs due to low volumes. Another goal of this article is to uncover the parameters that control the required trade-off between customer satisfaction on the one side and cost control on the other. The findings of this analysis will then strictly merge into a "catalog of requirements" for product design methods and may act as a reference during the evaluation of existent product design approaches for their goodness in mastering the balancing act between the two extremes of standardization and customization. Also Lampel and Mintzberg [6] share this view in their observations for which reason they maintain that:

"…customization and standardization do not define alternative models of strategic action, but, rather, poles of a continuum of real-world strategies."

The article is structured according to the three-step method applied. First, the various strategic options in compliance with present strategic management doctrines are highlighted and introduced in order to visualize the "poles" and the intermediate "continuum of real world strategies". In a second step, the different business-level strategies are equipped with corresponding system-level design regimes as they are established and proven in industrial practice. The third and very essential part is analyzing the previously identified design strategies for differences and commonalities which are resulting in the common product design parameters. The obtained findings are thereafter

transferred into general criteria and establish the “catalogue of requirements” for an integrated product design methodology to be developed.

BUSINESS STRATEGIES: THE BACKBONE OF ANY PRODUCT DEVELOPMENT EFFORT

As it became yet evident in the introductory part, the transition of the two extreme poles of maximizing cost efficiency through standardisation on the one hand and increasing revenues as a result of improved customer satisfaction on the other hand is blurred. Hence, it is for a good reason that Lampel and Mintzberg [6] name this interspace a “continuum of real-world strategies” rather than defining distinct borderlines, since the latter simply wouldn’t come up to reality. Consequently, the challenge for strategic management as well as involved design engineers is obvious: there is a likely risk of opting for a merely suboptimal business strategy considering the on-hand business environment without ever getting to know or, even worse, becoming apparent way down the curve of the product development process. Thus, there is an obvious need for a comprehensive, business-strategy spanning support tool that is allowing to do both analyzing the economic performance of the product as it is designed according to the predetermined strategy and simultaneously overlook plausible strategic alternatives to after all assure an optimum profitability of the particular customer solution.

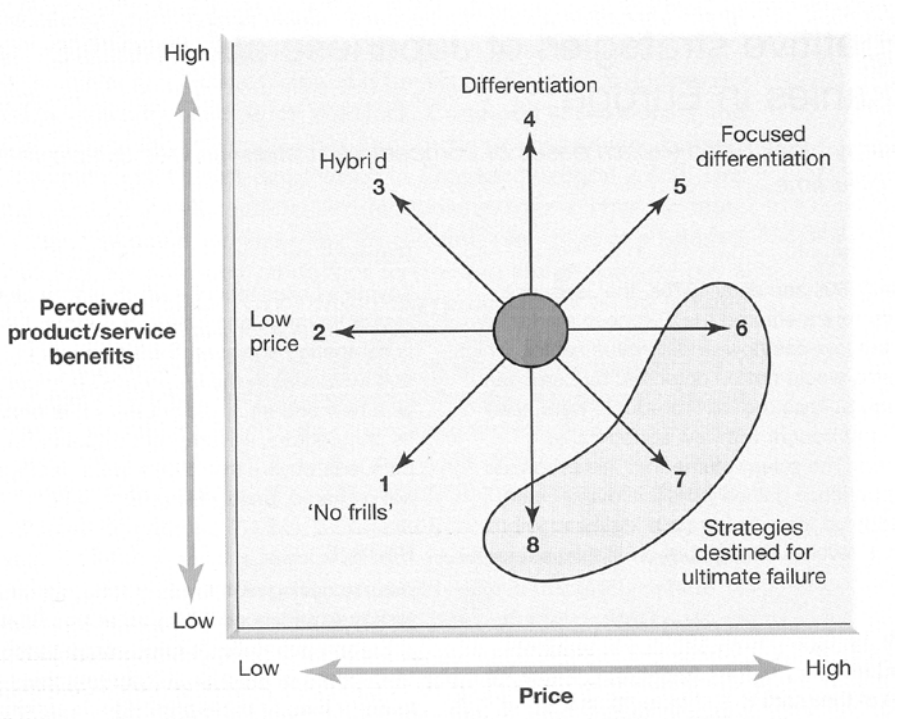

Figure 1 “The Strategy Clock”: Highlighting the various strategic options on the Business-Level [5]

On this account, the various business strategies as proposed by current strategic management doctrines shall be recalled in the first place. The so-called “strategy clock” introduced by Johnson et al. [5] has proven to be a valuable, since illustrative, tool for this purpose (Figure 1). Thanks to its highly self-explanatory character a further illustration may

be waived in this context and instead be referred to accordant literature. Moreover, the major concern of this article is to create the systematic link-up between corporate strategy and product design, that is, successfully delivering the corporate message to product engineers and via the product to final customers. On this account, first of all abstract strategic management terminology had to be altered in order to satisfy precise engineering specifications. Therefore, "perceived product or service benefit", previously applied as a measure for product value, is from now on going to be replaced by "AVERAGE CUSTOMER SATISFACTION", that is an expression for a product's adaptability to its potential buyership. In turn, the rather unclear term "price" is substituted by "PRODUCTION COST" as an accurate measurement for a design's cost base respectively economic efficiency.

TRANSLATING STRATEGIC SPECIFICATIONS INTO TECHNICAL TERMS FOR DESIGN ENGINEERS

Having identified the various strategic alignments on the business unit level, the second step of the method is now concerned with linking them to corresponding product design approaches as they are proven and established in industrial practice. Figure 2 grants an insight into the nature of the various product design strategies and their specific capabilities in adapting to discovered customer needs. The illustration thereby shows the relationship between average customer satisfaction and the respective degree of product sharing, that is the amount of a product design's overall buyership (# of customer types) divided by offered product variations. This rationale is thereby following the basic logic of "the more different customers need to get along with one offering, the more unsatisfied they need to be" due to insufficient reflection of customer desires in the single product. Doubtlessly, there is being found a certain share of buyers that might be thoroughly satisfied with one specific offering for which reason the criterion of "average customer satisfaction" was created. The circumstance becomes obvious by considering the two extreme poles, custom and standardized product: whereas in the former, products are individually developed towards even single customer orders (in the extreme case), in the latter, the design is considered the more successful the more customers it may embrace (economies). Accordingly, customized design features the (theoretically) highest satisfaction rate amongst the below shown design strategies.

As it became yet apparent, the introduced design paradigms show varying emphases. In order to adhere to the previous examples, standardization is strictly following the principle of economies of scale that is reducing production costs till the edge (price-based). In contrast, customized products are not primarily concerned with production economies and involved sales prices as in fact on utmost product performance (customer-based). Modular product platforms instead take an intermediate position in this hierarchy, since they are well capable of balancing the extremes of both, customer orientation and economic efficiency.

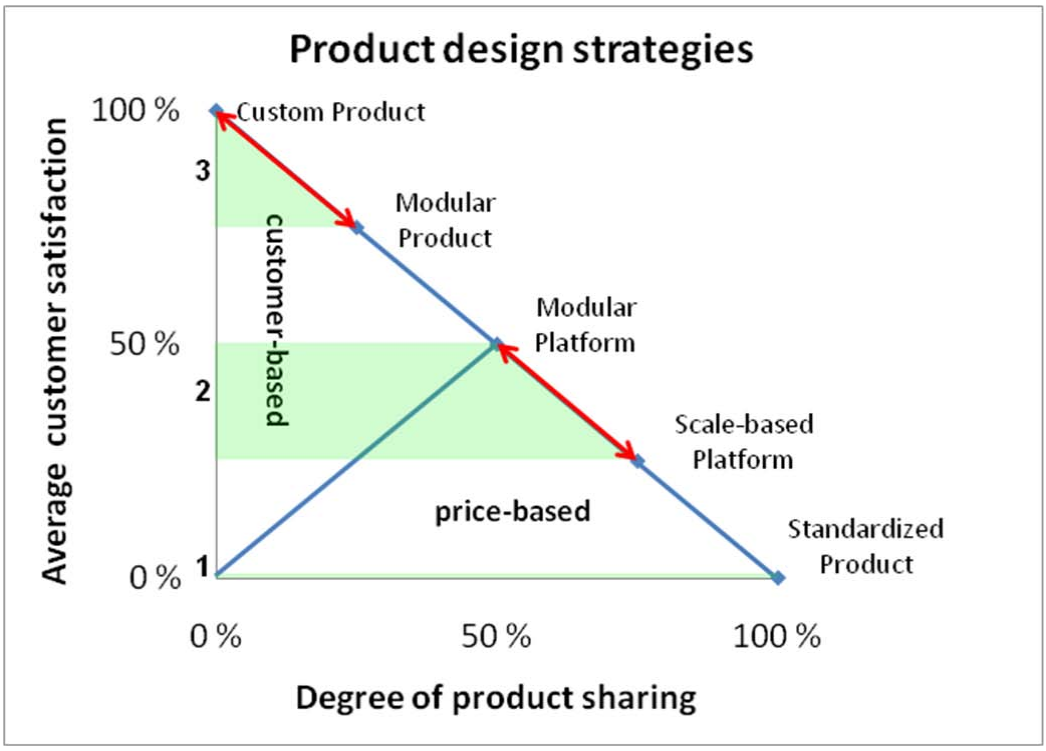

Figure 2: The various product design strategies defined by average customer satisfaction and product sharing (schematic). Thereby three major design strategies become apparent: 1) low customization, 2) price-sensitive customization and 3) performance-sensitive customization.

Following Figure 2, there are moreover plausible design alternatives away from customized products and Modular Platforms towards improved cost-efficiency dependent on individual company and customer preferences. Thus, modular product and scale-based strategies open up an array of design opportunities with varying emphases on customer orientation and cost-efficiency on both levels, price-based and customer-based. After all, three major design strategies emerge:

1) Low customization – optimizing economies of scale for a competitive cost-base
2) Price-sensitive customization – increasing revenues at a superior cost-base
3) Performance-sensitive customization – special purpose, low-volume products

Having accomplished a rough classification of the various product design strategies in accordance to the individual degree of customization, they shall be further elaborated now. Therefore the design approaches have been transferred to the initial situation of the "strategy clock" for explanatory purposes (Figure 3). In the meantime, the parameters have been changed to "average customer satisfaction" and "production cost" instead of the previous criteria "product benefit" and "price" in order to satisfy precise engineering standards. The explanations will proceed from the low-customized end onwards.

1) Low customization

Standardization

First time implemented on a large scale by Henry Ford, standardized products are ideal for the automation of (whole) production processes – an idea emerging during the 1980s – which was regarded as the remedy for long lead times, quality problems due to difficult assembly operations, monotonous work (see also "Taylorism"), bad ergonomics and heavy administration as a result of high part counts [1]. However, it does not solve all problems since multiple part numbers complicate material handling, automatic feeders may rarely handle more than a few different types of components and the layout around automatic assembly lines turns out to be often space demanding. Further, automated systems proved to be less flexible than corresponding manual assembly and, thanks to heavy investments in machinery, standardized product designs are naturally rigid for change and development. Consequently, standardized design should not be applied in rapidly changing business environments where flexibility is a key criterion. Otherwise there is a likely risk of exceeding product variants swallowing the positive effects of speeded-up assembly and superior quality.

→ successful strategy in e.g. process-intensive industries (bulk products) and commodity goods (grocery chains)

2) Price-sensitive customization

Scale-based platforms

Initiated at the edge of the 21st century, scale-based platforms put a focus on shortening development lead times and increasing commonality between products. The conception is, of course, cost reduction in development and production through sharing common components and technologies between the different product variants. Thereby, a platform design is considered to be the more successful the higher the degree of commonality and the better the products overall performance. As a consequence, products turn out to become fairly integrated which in turn results in physically similar products that are merely distinguishable by their overall performance such as speed, size, power etc. In this context Erixon [1] observes *"a risk with product platforms...that the products may lose their identity – their profile."* and further *"may compromise the brand image and result in decreasing sales volumes"*.

→ Scale-based platforms are successfully implemented where high degrees of customization may easily be disregarded and, in fact, the degree of optimization and price level are crucial in purchase decision-making. Examples include Pratt & Whitney jet engines [8], and Black & Decker universal motors [7].

Modular product platforms

Modular product platform designs are approaching profit creation from both sides, cost-cutting through shared components and technologies – just like scale-based platforms – and increasing revenues by flexible product adaptation towards (ever) varying customer demands. Unlike the predecessor on the "strategy clock", modular product platform designs are consequently the more profitable the higher the amount of products sharing the same components (economies of scale) and the better products may satisfy individual customer demands. In order to optimize the cost-base of the design however, it should be spread across as many marketplaces as it is technically feasible with all the challenges diverging customer requirements implicate. This seemingly paradox situation may only be solved out by physically separating parts that control individual customer desires from those that are kept common throughout the product family. Once mastered though, many variants of final products serving different market segments can be covered without increasing a company's internal complexity also referred to as "mass customization". Due to the building-block-structure, this product design turns out to be extremely flexible and therefore is very suitable in fast changing business environments. However, the price for high flexibility and reduced complexity may be a somewhat diminished overall product performance for which reason this design is an option for markets where such integrated measures like size, efficiency, output and weight for instance are of subordinate importance.

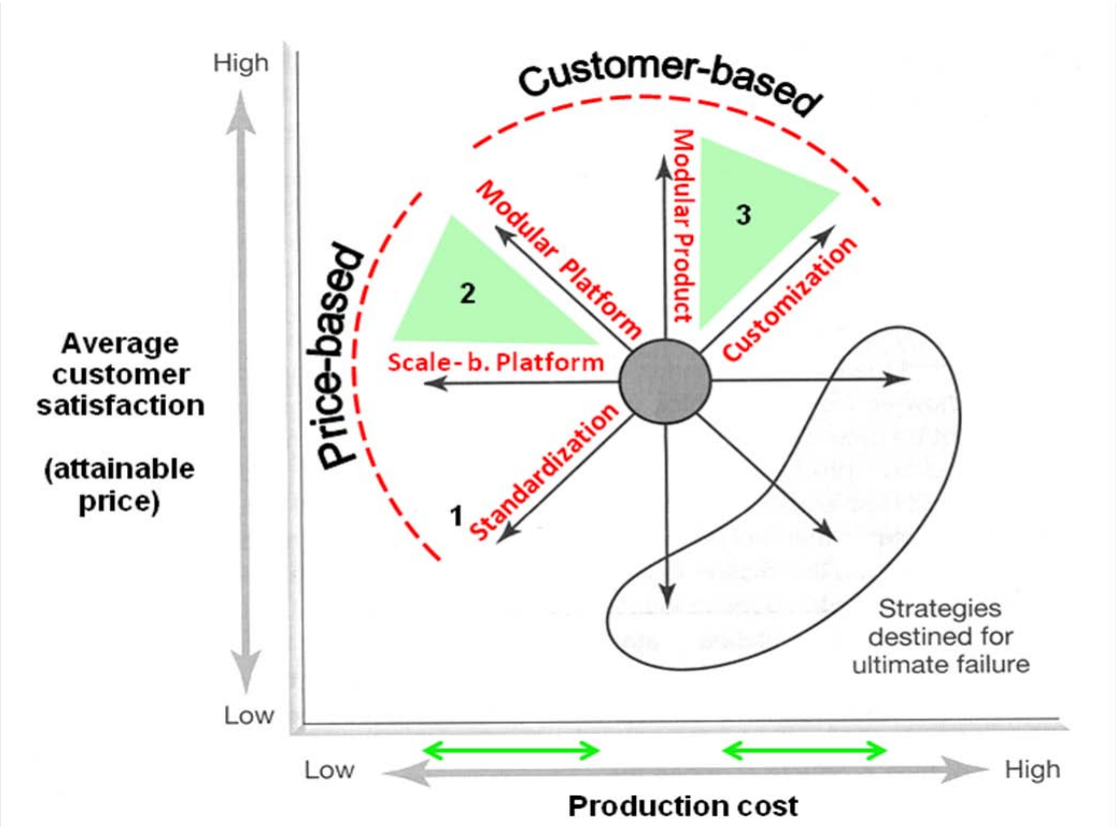

Figure 3: The original outlay of the "strategy clock" now enriched by relevant product design strategies. As opposed to the first major design strategy, Nr. 2 and 3 embrace a multitude of plausible design configurations for which reason they emerge as a blurred interspace here.

→ Industrial examples where modular product platforms have been excelling in range from the Sony Walkman™, via Scania truck cabs [1] to the Black & Decker power tool family [7].

3) Performance-sensitive customization

Customized product

Customized products, as the denotation yet suggests, are usually targeted at individual market niches or even single customers in an often made-to-order context. Hence, flexibility does not depict a key design driver as products are made-to-measure and not produced unless a potential client has pronounced its personal features or a firm is originally constraining its operating range to a single market niche, respectively. As a consequence, products do not need to be designed around building blocks as in the previous example and instead may be straightforwardly optimized to their later field of application. This naturally leads to a rather integrated product architecture for which reason customized designs are a great option in high-performance implementations or unique circumstances. As a result of the high degree of specialization however, customized products often turn out to be extraordinary pricy unless sales volume and market share allow for large-scale production (economies). Another flaw is a generally weak flexibility which, in fact, may be avoided by careful business model selection.

→ Cases of successful customization strategy implementation are manifold and numerous those of which should be mentioned the delivering project businesses in here e.g. ship construction and power plant production [2].

Modular product

Modular product design is representing the counterpart of customized designs in the field of performance-sensitive customization – just as scale-based and modular platforms in the area of price-sensitive customization. Unlike customized products however, modular designs are not exclusively constrained to single market niches, rather they are capable of embracing, for instance, all market niches within a specific segment (“market segmentation grid”, [7]) thanks to the above described building-block-system. Accordingly, it is possible for the customer to compose the product by choosing amongst a given variety of options for selected product functions due to standardized interfaces and carefully separated building blocks. This significantly enhances flexibility and efficiency as opposed to designing from scratch, each time a new customer desire is emerging. As it was yet observed however, global product performance features may rarely be met by modular architectures [11] which in turn necessitates green-field development.

Unlike the platform relative, modular product designs merely feature a fixed set of functions which renders them incapable adapting to more than one market segment. Consequently, there is no possibility for leverage by spreading common functions across multiple market segments involving poorer economic overall performance as opposed to the modular

platform counterpart for instance. In fact, reality shows that 'design for platform' is not always technically feasible (e.g. unrelated or very specialized segments) and moreover strategically plausible as platform development induces a significant cost-extra (time, resources) holding an explicit risk in case of failure [11]. On this account, for many companies 'design for platform' is not an option respectively at a later point in time when the risk, usually involved in new product development efforts, is manageable.

→ prevalent approach in the consumer goods business, e.g. Swiss Watches [7]. Increasingly customers are asked to enter their preferences into configuration software which thereafter composes the "customized" product ready for purchase.

The above illustrated product design strategies for both price-sensitive and performance-sensitive customization merely highlight the extreme positions towards either the modular or the integrated direction in the respective field. Consequently, they span a space of intermediate design options where it is essential discovering the optimum solution on the basis of the organization's business environment and individual strategy directives. An appropriate method, able to visualize and analyze the varying design performances may be helpful in the decision-making process, especially under complex product circumstances. The next section according to the methodological prescription comprehends the identification of common influencing factors by which all the product design approaches discussed in the context of this article are determined. This is in order to define the specifications for an adequate design support tool to be applied in engineered products industries.

RESULTS

1) Common parameters controlling product design

Reflecting on the above considerations, several factors appear that enable a link-up of the various product design strategies towards a coherent scheme (Figure 4). Hence, a closer look uncovers peculiarities within as well as between the two major levels on the way up of the customization ladder.

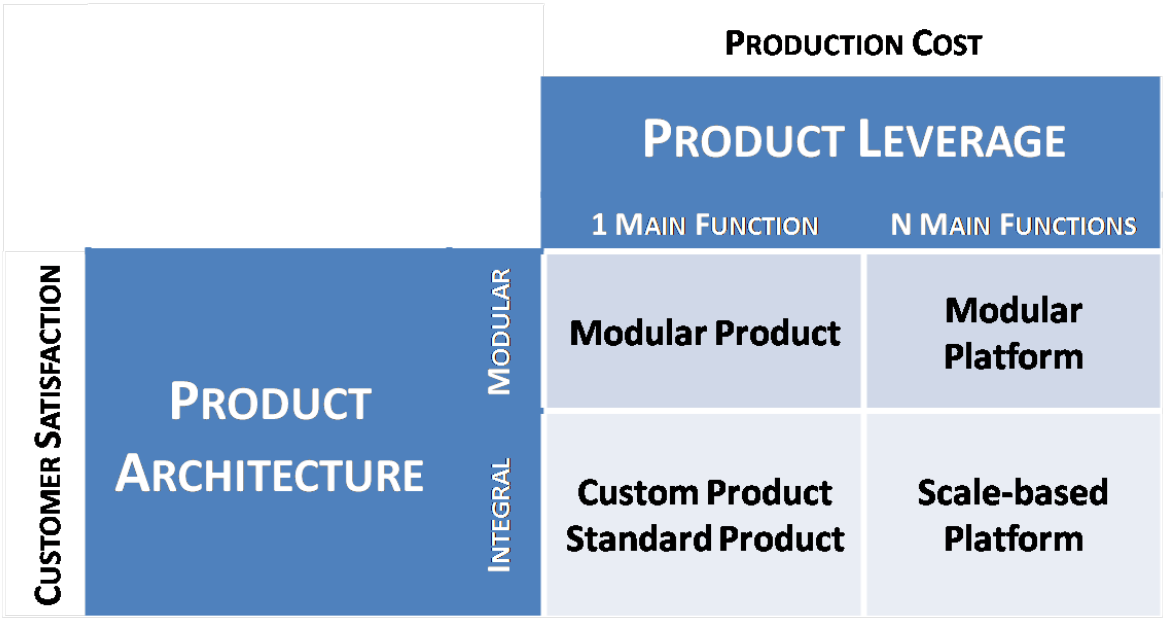

Figure 4: The various product design strategies (matrix) now defined by their common design drivers as they could be derived from previous business strategy analysis

Facing both of the major levels simultaneously, it becomes apparent that the range within of which a product's individual architecture may vary remains common, although the whole objectives are still significantly differing. It is now about to shed light onto the receivable extreme values, namely modular respectively integral architectures, in order to identify the first common parameter behind product design.

The concept of modularity is far from new and traces back to the ancient Romans where the word modulus was used as a unit of measure in classical architecture, although the term module had a purely structural meaning at that time. Thus, the term is originating from and influenced by architectural streams. Hence, during the era of Functionalism at the beginning 20th century (Bauhaus school), the idea of combining standardization with functional thinking received more attention and for the first time functional user requirements ought to be linked up with industrial production efficiency. However, functionality aspects weren't yet coupled with the modules rather they were defined by their interface geometry ('building blocks'). More recently and particularly in the mechanical engineering and engineering design, the linkage between modules and technical functions is emphasized [9, 11]. Consequently, modular product architecture needs to feature the following two properties according to present definitions [11]:

1) *Chunks implement one or a few functional elements in their entirety*
2) *The interactions between chunks are well defined and are generally fundamental to the primary functions of the product*.

Accordingly, the most modular architecture is one implementing each functional element of the product by exactly one physical block and where are few well-defined interfaces between the chunks. As a matter of course, such architecture inherently allows a design change to be made to one module without requiring changes to another enabling independent module design. More modern research however suggests that by means of specific metrics, flexibility between modules may be maintained though incorporating more than only one functional element ('redesign flexibility metric') [3].

Consequently, it is the independency between the various modules that may well be considered as the central element in modularity, because simply without it, a single module wouldn't be more than a conventional subassembly or subsystem. In fact, it is the independency criterion that triggers a multitude of advantages such as high flexibility/variability, reduced product development lead time, simultaneous development of product and production, improved quality, service and upgrading and leaner administration.
On the other hand, the deliberate separation of product functions into independent physical elements may cause under certain conditions technical performance trade-offs in comparison to their rather integrated counterparts in the field. Following Hölttä-Otto [3] and Whitney [13] there is a tendency away from modular product structures as soon as entering the field of products with generally high technical and therefore optimized performance requirements, e.g. high power mechanical products. They maintain that on those occasions a modular product is most likely larger, heavier and less energy-efficient. Or the other way round, using Ulrich & Eppingers' remarks on product performance [12], modular product architectures less likely succeed in business environments where *'global performance characteristics'*, such as the afore mentioned, are sales-relevant. Due to volitional independency of the various product elements, optimization efforts may only take effect unless reaching relevant module boundaries. That is what Ulrich comprises with the term *'local performance characteristics'*.
This moreover explains the necessity and existence of the integrated equivalent in either sector the price-sensitive as well as the performance-sensitive. Again citing Ulrich [11], an integrated architecture exhibits one or more of the following characteristics:

1) *"Functional elements of the product are implemented using more than one chunk.*
2) *A single chunk implements many functional elements.*
3) *The interactions between chunks are ill defined and may be incidental to the primary functions of the product."*

According to the previous definition integrated products are characterised by product functions spread across multiple parts of the product (components), thus satisfying *highest possible performance criteria* (optimization) and often disguised or even non-existent boundaries between the various product sections. In a similar vein as functions may be distributed across the entire product, they may be combined into a few physical components in order to *optimize dimensions* of performance (size, weight) also known as function sharing. In the first case, modifications to any one particular component or feature may cause extensive redesign of the product since sections to be switched or modified are

not separately accessible or alterable without significant interference of residual components. The same applies to the second case unless functions to be integrated within physical elements were not wisely selected under consideration of interface complexity (see 'redesign flexibility metric') and product strategic aspects. Thus, consequently accounting for these criteria, also products designed along a modular regime may well be competitive in dimension-sensitive business areas.

Practice shows [3] that the truth lies somewhere in-between on the one hand fully modular architectures where one function is explicitly accommodated by one physical component of the product and on the other hand completely integral structures where all functions are placed within a single physical unit respectively one single function is spread across multiple/all product sectors. Thus, facing the involved risks and tradeoffs in either extreme case, it is not surprising that real-world products feature a more or less modular architecture with relative amplitude to either the modular or the integral direction, dependent on the particular business environment and its customer preferences. Since the ultimate goal of business though is profitability, the cost-side which is including e.g. total production, redesign and development costs and which may significantly vary for each design option, is often the crucial criterion when opting for one certain product architecture.

Having discovered the first common product design driver (product architecture) that moreover turned out to be of likewise significance to both the performance-sensitive and the price-sensitive customization level, it is essential to shed light onto the major differentiator in order to determine the second parameter. Hence, as it appears from Figure 3, the platform representatives decisively outperform their high-end customization counterparts in terms of cost-efficiency. This section will now be concerned briefly introducing strategic rationale for either way as found in corresponding literature and thereafter classifying the examined product designs on grounds of performance characteristics to demonstrate the impact of the structural differences on cost-efficiency.
Yet mentioned in the previous chapter, each and every one of the product design strategies takes advantage in certain business environments as it turns harmful in others. According to this, performance-sensitive strategies are specifically favoured in so-called *Market-Pull* contexts where an opportunity for a promising product solution is spotted and appropriate technologies are developed or selected in order to outperform present competitor offerings. In accordance with Ulrich and Eppinger [12], classic applications are found in the consumer sector like sporting gear, furniture or tools to be mentioning a few. Further, circumstances often privileging performance-sensitive strategies are *Technology-Push* (contrary to market-pull; new technology is discovered and requires field of application, e.g. Gore Tex), *Customization* (response on special customer desires; characterized by highly detailed development process and individual design values) and *High-Risk* (high given uncertainty regarding technology, market place, budget and schedule) business areas. Even though technically feasible in some of the aforementioned cases, an initial constriction/specialization is advisable from a strategic viewpoint here – hazarding the consequences of a momentarily diminished economic efficiency.

Though overcome initial flaws in newly developed technology and having proven its utility in meeting customer demands as well as controlling development inherent risks, an expansion of firstly limited product deployments may well be contemplated. This discloses a multitude of cost advantages (price-sensitive strategies). Hence, subsequent products built upon platform designs (derivatives) are significantly simpler to develop as opposed to green-field designs due to shared components within the product family (commonalities). Moreover, Ulrich and Eppinger [12] mention a potential cost sharing effect as a result of development costs spreading across multiple variants ("leverage effect"), though higher front-end expenses for platform development may initially be met with criticism. As a result, platform designs are even qualified to advance into marketplaces that otherwise did not justify the development of a unique technology. Due to the obligatory design flexibility (standardized interfaces) platform designs are a specifically suitable strategy in the context of complex system industries (e.g. electronic, mechanical engineering).

Though recommendable from a strategic standpoint, the wish to create a product platform is often subdued by technical restrictions which shall be emphasized in the following. In accordance with established engineering design paradigms a product is defined as "a system that realizes a given internal function" [4]. Pahl and Beitz [9] take this approach one step further and decompose a system into subsystems so that the system architecture can be looked at different levels of abstraction. Consequently, a system is designed to satisfy one main function as it was directly derived from customer and market analysis [1]. Recalling the above said on the situational preferences of modular and integral product architectures, a main function has to exhibit rather local or global performance characteristics accordingly. On this account a main function shall be defined as follows:

"(1) A main function of a product or system is realized by the mutual interaction of global and local performance levels and is ultimately dependent on the customer requirements.

(2) The main function of a product or system can be modified by adaptation of either the global or the local performance level.

(3) In case both performance levels require changes simultaneously in order to embrace customer demand, a new and from the previous independent product or system needs to be designed."

Hence, Hubka & Eders' product definition [4] may be altered towards the product *as a system that realizes a given main function*. In other words, a product is determined by the main function it implements which in turn implies two products not to be considered different unless their main functions are – be it on global or local performance level or both (1st notion).

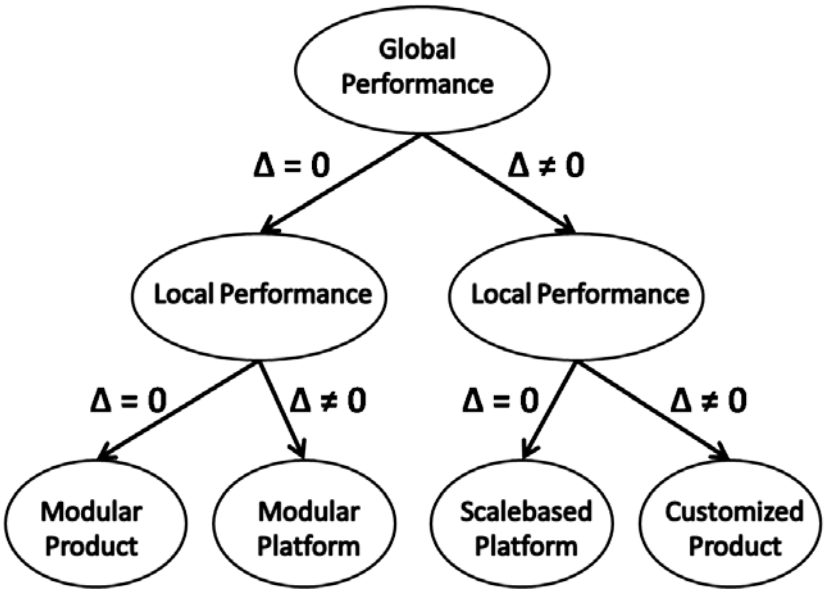

Figure 5: Definition of the four major design strategies based on global and local performance difference (main function notions). For platform suitability only one performance stage is allowed to change in order to not compromise the cost-efficiency surplus.

The above classification is specifically important in the light of product platforms discussed here, since a platform – modular or scale-based (integral) likewise – may only be deemed such if it spans not less than two different products or main functions respectively (2nd notion). Thereby this notion is not to be mistaken for 'product variation' which is no more than a different option model of one and the same product concept (main function).

Figure 5 illustrates the above introduced main function notions and their impact on the four major design strategies given that corporate guidelines don't prescribe any different. Consequently, a *modular product* is not intended to accommodate performance changes on global or local level for which reason it may embrace merely one main function. In a similar vein, *customized products* are aiming for one main function implementation. As the name yet suggests, they are strictly designed towards the client's individual performance perception.

For cost-efficiency excellence however, one product design must aspire launch on as many marketplaces as possible to achieve the essential economies due to shared production and development costs. As initially mentioned this is subdued by technical constraints since such design requires managing a multitude of different customer demands on global and local performance levels. Though, simultaneous change of global and local levels would entail an exhaustive extra in development cost (3rd notion) and therefore undo the potential of cost

savings, a required main function change may be executed on either the global (‘*scale-based platform’*) or the local performance level only (‘*modular platform’*).

2) Catalogue of Requirements for Integrated Product Design Method

Thanks to a holistic procedure combined with structured analysis of both the business strategies and the accordant product design equivalents, it was able to identify a coherent scheme of influencing factors generally driving system-level design (Figure 4). Based on this a catalogue of requirements for an integrated product design method is derived the latter of which shall replace dated, subjective, single-edged or otherwise insufficient existent design methods and enable organizations to fully exploit their resources and competencies. Thereby the general criterion is:

Support of *performance-sensitive* (one main function/single product) as well as *price-sensitive* product designs (multiple main functions/multiple products).

This requires in detail:

1) Support of *modular and integral* product architectures (local and global performance characteristics)

2) Identification and *separation of common* from customized product sections

3) *High reliability* for application in a complex system context (quantitative aid)

4) Consideration of company-internal or project dependent *design drivers* (including selection and individual importance weighting)

5) Optimization of product architecture towards *maximum profitability*, that is, best possible performance (global & local) at lowest possible overall cost (production/assembly, development + contingent redesign cost)

Conclusion

One major task at the outset of this article was to shed light onto the mutually exclusive correlation of customer satisfaction and therewith organizational revenues on the one side and the risk of poor economic performance as a result of a multitude of similar products on the other side. Another goal of this theoretic study was to uncover the common parameters that control the aforementioned trade-off between customer satisfaction and cost-efficiency clearing the way for a general “catalogue of requirements” including the essential criteria to an integrated product design method. For this purpose a three-step approach was chosen. First, the array of business-level strategies as the later field of application was examined in order to incorporate the appropriate system-level design regimes in a second step. The third and crucial section of this work was concerned identifying peculiarities within

as well as between the various customization levels resulting in the common influencing factors product architecture (modular versus integral) and product leverage (single versus multiple main functions). Moreover, established design paradigms could be altered by the 'main function notions', now allowing for explanation and identification of platform suitability in e.g. existent product families. The ultimately derived 'catalogue of requirements' including its postulation for optimized product architectures consistent with the accordant business environment, thereby sets the benchmark for existent and future system-level design approaches.

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DEVELOPING A HYBRID MODEL FOR REMANUFACTURING FACILITY LOCATION PROBLEM IN A CLOSED LOOP SUPPLY CHAIN

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ABSTRACT

In today's competitive environment, the movement of raw materials to processing units, components assembly plants, and finished goods plants throughout the supply chain are crucial. On the other hand, design of supply chain is usually based on an open loop configuration or forward flow of materials, which means that the recent attentions from governments, manufacturers, and customers for recovery of materials are not considered in supply chain in spite of their importance. In our research, we are going to design a closed loop supply chain constituted of suppliers, manufacturing plants, warehouses and distribution centers, customers or retailers (which are characteristics that form the generic configuration of facility location problem), and also we add new concepts of recovery centers, and remanufacturing plants and try to find the optimized location for these facilities in a discrete space. In uncapacitated facility location problems (UFLP), there are usually uncertainties about future factors such as customer demand, price of land, pool of expert labor, government's regulations, and other factors which put restrictions on decision making about facility locations. To cope with the vagueness's of factors; we will implement the concepts of artificial intelligence, and will use the fuzzy sets to simulate restrictions of our suggested new facility location decision which consist two new tiers and use them to solve the problem. Since our main object is to locate new facilities, fuzzy TOPSIS methodology will be implemented to find the best place.

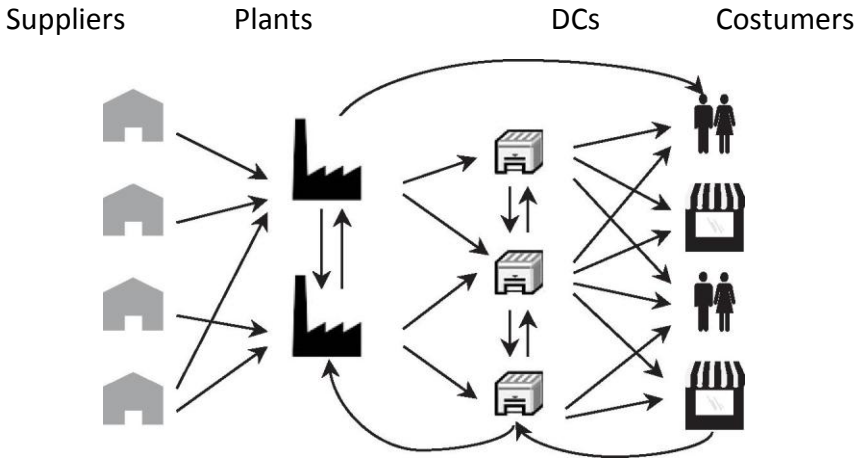
Keywords: recovery facility; remanufacturing; fuzzy TOPSIS; Facility location.

INTRODUCTION

A traditional supply chain is an integrated system which synchronizes a sequence of manufacturing processes in order to acquire raw materials and parts from suppliers, convert these raw materials and parts into finished goods, which increase value of raw material and change raw material to final products, distribute and promote the final products to either distributer centers or final customers. The main objectives of a traditional supply chain are to provide better movement of information, increasing competitiveness and profitability of firms, effectiveness and efficiency throughout the supply chain. This aim can be achieved by increasing efficiency and effectiveness of all tiers in supply chain, then whole supply chain will experience a better productivity which in turn will enhance the profitability of the firms which constitute the supply chain. Usually a generic supply chain is constituted of four tiers which are suppliers, manufacturing plants, distributions centers, and customers respectively [1] as fig1.

Amongst the strategic decisions is deciding where to locate a facility to best adapt with other tiers of supply chain and also best serve the costumers. This problem has devoted a fruitful and rich literature to itself and is known as facility location decision and has a long term effect and cannot be modified easily. By the definition, supply chain is divided into two major categories, centralized and decentralized [2]. In a centralized supply chain, decisions about strategies or long term plans are made at the strategic level, usually these decisions have a long term effects and cannot be changed in short term except by a huge cost and long period of time.

Fig1: A generic supply chain with four tiers.



In a generic supply chain there are many problems to deal with such as procurement, production, inventory management, distribution of goods, logistics or routing, and may be the most crucial of them facility location decision. In fact, in addition to all canonical management consideration supply chain designer should answer questions about manufacturing decisions,

inventory policies, information sharing between tiers, and location of plants and distribution centers all to design a perfect supply chain for profit maximization [1, 2].

Usually decisions about manufacturing, inventory, and procurement of materials may be modified due to the changes in conditions (such as availability of raw materials, labor costs, component prices, transportation costs, inventory holding costs, exchange rates and tax codes [3]) and in short term, but decision about facility location, once it is made, cannot be changed easily even in long term. Selection of inefficient locations for production and assembly plants, distribution centers, and warehouses will result in excess costs throughout the supply chain; no matter how precisely the production plans, transportation options, inventory management, and information sharing decisions are designed in response to changing conditions. So designer of supply change must consider and include all the affecting factors in decision making about location of facilities before locating any facility in supply chain [1,2, 3].

Some of the affecting factors that designers should consider are costumer consciousness, government legislations for used products, and most important of them manufacturing cost of products. During the last decades, manufacturers were seeking ways to reduce production costs; meanwhile their products were distributed and used by consumers until they were wasted. These wasted products were left in environment causing environmental costs and landfills. Environmentally consciousness of people all around the world had made governments to legislate rules for remanufacturing products that make manufacturers responsible for collection of their used products and reuse of them in new products and also avoid production of waste materials. These factors have led supply chain designers to closed loop supply chain. This new concept requires inclusion both forward and reverse logistics in supply chain. Traditional supply chain implement forward flows of materials, moving them from suppliers through supply chain to costumers. Sometimes, reverse logistics take place simultaneously to forward logistic, moving used products from costumers to remanufacturing plants. But in order to form a closed loop, there must be logistic of materials from remanufacturers to suppliers, manufacturers, and also directly to customers [1-4].

Combination of these two concepts will constitute closed loop supply chain which is environmentally consciousness, and since in this configuration new materials are not needed except for substituting those materials which could not be recovered from end users returned materials, so the cost of production will considerably decrease [19, 20,21].

The reminder of this paper is as flows: section 2 comprises literature review about reverse logistics and the necessity for embedding recovery centers in supply chain to constitute closed loop supply chain. Our methodology for locating remanufacturing facility will be explained in section 3. Also the main problem of locating the new facility based on fuzzy TOPSIS is explained in section 4, prior to conclusion of the method and suggestion for future researches in section 5.

LITERATURE REVIEW

By the advent of sophisticated manufacturing practices, and with recent attentions made to customers; which ultimate efforts are made to satisfy customers throughout the supply chain, and also with the new regulation legislated all around the world to reduce, reuse, remanufacture, and recycle, supply chains have changed their generic configuration to new enhanced mode which can deal with all the expectations from suppliers to the end customer in forward logistics and from costumers to manufacturers in reverse logistics [19, 20].

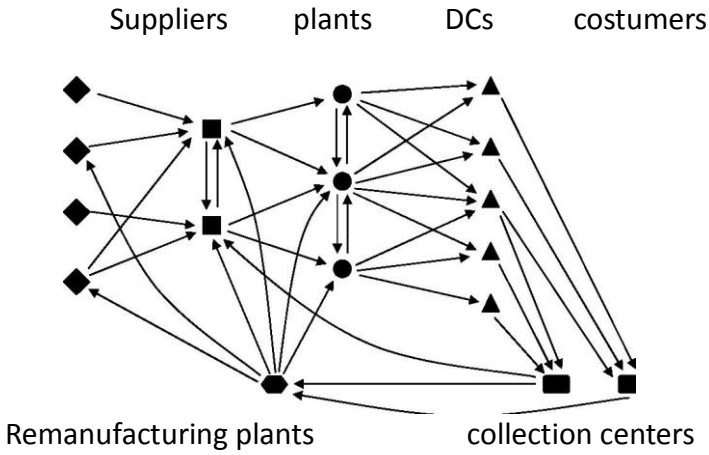
The definition of reverse logistic based on the American Reverse Logistics Executive Council is" "*The process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal*"[20, 21].

Recent focus is on remanufacturing and recycling which are the main pillars of reverse logistics and constitution of closed loop supply chain. Remanufacturing is an emerging concept in manufacturing and refers to refurbishing used products returned by costumers by substituting degenerated or defective components, and reselling the product. This can be accomplished by original manufacturer (OM's) or another company. There are a number of important reasons for doing this. First is that a remanufactured product can be sold for about 50% of the cost of a new product. Second is that the process requires mostly unskilled and semiskilled workers, which is very interesting for developing countries. And finally in the global market, for instance European legislators are increasingly requiring manufactures to take back used products and also design and fabricate products that are recyclable (Design for recycling) and a specified percent of parts are able to be disassembled (Design for disassemble)and remanufactured as new products or recyclable parts to be recycled, this means fewer products end up in landfills and there is less depletion and waste of natural resources such as raw materials and fuel [19-22].

All the factors mentioned above have led designers to a new configuration for supply chain which is closed loop supply chain. In fact closed loop supply chain has been formed by two different concepts and flow of materials; reverse logistic which connects customers or "end of pipe" users to remanufacturing plants and transfer cores form costumers to remanufacturing plants, and "forward flow" which transfer remanufactured product directly to customers or to manufacturing plants[19, 20, 22, 23].

In this configuration shown in fig.2, uncapacitated facilities, called remanufacturing plants and recovery centers, are located in supply chain to serve all the tiers not only to collect returned product at any level of production (from material in process, semi finished goods, or final product), but also products that are damaged, have any faults or malfunctions, discarded by consumers after end of life cycle.

Fig2: New configuration to form closed loop supply chain.



In general, a closed loop supply chain design starts with the identification of potentially interesting sites for new facilities and the required capacities. Typically, large amounts of capital must be allocated to a new facility, either recovery centers or remanufacturing plants, thus making this type of investment a strategic decision [1]. Therefore, facilities that will locate are expected to operate for an extended time period. Future changes of some factors during a facility life time can change a good decision to a poor one which can cause lose of profit, or customer dissatisfaction. Accordingly, sophisticated facility locations decisions should consider all the crucial factors which may change a good location decision to a poor one [19, 20, 23,24].

V. Jayaraman et al [19] state that the flow of materials can take place in both directions of forward and reverse logistics. They develop a mixed integer linear programming model that deal with location of new facilities and also transshipment, production, and stocking of the optimal quantities of remanufactured products and cores. Although they mentioned that collection of goods in reverse logistics is supply-driven flow, and usually there is uncertainty about return rate and demands of customers, hence they build up their location model, neglecting this aspect of closed loop supply chain design.

Although Z.Lu and N.Bostel [20] consider remanufacturing, based on benefits and possibility, as main option of a recovery system, they include other characteristics of closed loop supply chain such as reuse, repair, refurbishing, cannibalization, and recycling. In their model, since recovered products are introduced as new products, interactions of forward and reverse flow were considered simultaneously. For purpose of modeling, they assume that the product demand and available quantities of returned products at the costumers are known and deterministic and based on this assumption they formulated an uncapacitated facility location model for remanufacturing network system. The objective function of their model is to minimize total cost including fixed and variable costs.

Since the efficiency of reverse logistics mainly depends on facility location decisions, Y. Zhang, and J. Xu [21] formulated the facility location problem as to minimize sum of transportation and

operation costs. They proposed a mixed integer programming model for facility location problem. Here they consider the demand and capacities as uncertain parameters, so their model was hybrid. Their model is very basic for the facility location and can be used in traditional supply chains, without implementing concepts of reverse logistics to form closed loop supply chain.

Focusing on 3R's operations concepts in green supply chain, H.F. Wang, and H.W.Hsu [22] also try to optimize logistics and location selection. They divide closed loop logistics model to two parts: forward logistic which deliver final product to demand points or costumers, and reverse logistics which is flow of used products for recovery. This system ensure of least waste of materials. They also consider distribution centers as collection centers and suggest that this distribution/collection centers have flexible capacities for distribution or collection of products. From their point of view, if the interactions of capacity in distribution/collection centers are not considered, the model is a "prolonged model of supply chain" without any loop. Finally they suggest an integer linear program model with given demand of customers and recycling rates which its aim is to minimize total cost of transportation and operations by determination of facility locations.

N.Ö.Demirel, H.Gökçen [23] emphasize on reverse logistics as an strategy for firms for making profit under competitive circumstances which deals with how to retrieve products from customers. They also consider the concept of recovery network for collection of used products to take them back into reusable condition and distribution to customers. In their research, recovery is accomplished through repairing, refurbishing, remanufacturing, cannibalization, and recycling. Finally, they provide a mixed integer linear programming model for remanufacturing in reverse logistics environment.

Although N.Ö.Demirel, H.Gökçen[23] in their research used numerical data to test their model, F. Schultmann et al[24] used an example of automotive industry to model the reverse logistics tasks in a closed loop supply chain considering the end-of-life vehicle (ELV) treatment in Germany. They suggest that there are two main distinct motivating factors to integrate product life phase into existing supply chain; legal and profit for tiers in supply chain. In spite of previous researches which consider products return as either waste stream system or a market driven system, they consider legal and profit as motivators for recycle or reuse of spent products. Accordingly, establishment of recovery network which ensures efficient coverage of demand and supply area is a crucial task of supply chain network designers for providing a free of charge return of products from demand points. Realizing recycling steps, they define the objective function to minimize cost for establishing a product recovery network and fulfill recycling goals [24].

In this paper we are going to design a material recovery system, which include product life expansion through repair, remanufacturing, and recycling based on decision makers opinion which is in fuzzy linguistic form. By incorporating traditional supply chain in which flow of materials take place in forward logistics and reverse logistics channels, a closed loop supply chain for material recovery will constitute. In this system suppliers are divided to two

categories; new material and used material suppliers. When components cannot be supplied by recovered materials, new materials are supplied by suppliers. Here costumers are suppliers of used products and demand point for new products simultaneously. Extensions of product life cycle accomplish by remanufacturing and repair systems which are the main part of recovery system in closed loop supply chain. Usual focus in remanufacturing is on management of material's (or cores) flow from costumers through reverse logistics to recovery and remanufacturing plants, and also from these plants to manufacturing facilities to produce new products for costumers in forward flow [19-23].

METHODOLOGY

Since there are many factors in a facility location decision, and the designer tries to choose best place to locate the facility to suite all the criteria's, this problem can be defined as a multiple-criteria decision-making (MCDM) problem, and TOPSIS which was first initiated by Hwang and Yoon [5]can be implemented for decision making. This technique is based on the concept that the ideal alternative has the best level for all attributes considered, whereas the negative-ideal is the one with all the worst attribute values. TOPSIS defines solutions as the points that are simultaneously farthest from the negative-ideal point and closest to the ideal point, and is successfully applied to selecting the location of a manufacturing plant [6, 7].

In the process of TOPSIS, the performance ratings and the weights of the criteria are given as crisp values. Thus, the measurement of weights and qualitative attributes did not consider the uncertainty associated with the mapping of human perception on a number. However, crisp data are inadequate to model real-life situations since the evaluation data of the facility location under different subjective attributes and the weights of the attributes are often expressed linguistically [6, 7]. Thus, a more realistic approach may be needed to use linguistic assessments instead of numerical values. Recently, some researchers have focused on the fuzzy TOPSIS method to solve the plant location selection problem [8, 9 10].

However, existing fuzzy TOPSIS methods are not efficient enough due to the fact that to obtain the "fuzzy positive-ideal solution" and the "fuzzy negative-ideal solution", fuzzy ranking approaches are used, even though it is well known that no one can rank fuzzy numbers satisfactorily in all cases and situations [6].In addition, it is tedious to calculate the distance from the ideal solution and the negative-ideal solution. To solve these problems in fuzzy decision-making, a new fuzzy TOPSIS approach is proposed. In this method, the ratings of each alternative and the weights of each criterion can be represented as triangular fuzzy numbers. The results of multiplication of rating and weight can be calculated as crisp numbers by the canonical representation of multiplication operation on triangular fuzzy numbers. Then, the "fuzzy positive-ideal solution" and "fuzzy negative-ideal solution" can be determined easily without ranking fuzzy numbers [6, 7].

In addition, the distance from the ideal solution and the negative ideal solution can be calculated easily, which makes the proposed method more efficient than existing methods [6, 7].

WHERE TO LOCATE A NEW FACILITY?

Since facility location is a strategic decision[1], in order to locate a new facility to form a closed loop supply chain, which can support all tiers and be supported by them reciprocally, the tiers must provide their opinions about location of new facility. Strategic decision means that senior managers will decide about location decision as decision makers for locating a new facility in order to remanufacture returned products from demand areas. These decision makers are representatives for suppliers, manufacturing plants, distribution centers, and costumers which are showed by D_1, D_2, D_3, and D_4 respectively.

Initial screening shows that four possible sites A_1, A_2, A_3, and A_4 are feasible candidates to choose base on the crucial criteria listed as closeness to manufacturers, availability of machines and tools, closeness to customers or demand points, and availability of proper logistics which are C_1, C_2, C_3, and C_4 respectively. In order to deal with poor definition of criteria's, linguistic variables are used which are in form of words and sentences to evaluate all the situations. These linguistic variables are then changed to fuzzy numbers.

The decision makers have weighted criteria's based on their positions in supply chain hierarchy as table 1.

Table2 shows the rating of four linguistic criteria under each candidate location, based on decision maker's opinion.

Table1: criterias weights

	D_1	D_2	D_3	D_4
C_1	L	L	H	M
C_2	VH	H	M	M
C_3	M	H	M	H
C_4	VH	VH	H	M

Table2: decision maker's ratings

Criteria	Candidate	D_1	D_2	D_3	D_4
C_1	A_1	VG	G	G	VG
	A_2	G	G	P	G
	A_3	G	VG	G	P
	A_4	P	P	VG	VG
C_2	A_1	G	VG	G	P
	A_2	VG	G	P	VG
	A_3	G	P	G	P
	A_4	G	VG	VG	G
C_3	A_1	F	P	G	VG
	A_2	G	G	F	F
	A_3	P	F	G	G
	A_4	VP	G	F	G
C_4	A_1	VP	G	F	VG
	A_2	P	VG	G	G
	A_3	F	G	P	F
	A_4	G	P	F	P

Tables 1 and 2 illustrate that all factors are in linguistic format, and it is necessary to change them to crisp numbers for ordinary operations. As mentioned before, there is an ambiguity associated with each factor and criteria, so in order to deal with this vagueness we use fuzzy sets and provide some definition of fuzzy sets and numbers [12, 13].

Definition1. ("Fuzzy set") *Let X be a universe of discourse. Where $\tilde{A}$ is a fuzzy subset of X; and for all $x \in X$, there is a number $\mu_{\tilde{A}}(x) \in [0, 1]$ which is assigned to represent the membership of x in $\tilde{A}$, and is called the membership of $\tilde{A}$ [12, 13].*

Definition2.*A triangular fuzzy number $\tilde{A}$ can be defined by a triplet (a, b, c) which means $\tilde{A}$= (a, b, c) [12, 13].*

Based on definition 1 and 2 and also normal scale in TOPSIS in which linguistic factor “low” is “0” and “very high” is “10” ,table 3 and 4 are defined as combination of these definitions to change each linguistic variable of weights to fuzzy numbers as table 3 and decision makers linguistic ratings as table 4.

Table3: Fuzzy linguistic for weights.

Very low(VL)	(0.0,0. 1, 0.3)
Low(L)	(0.1,0. 3,0. 5)
Medium(M)	(0.3,0. 5,0. 7)
High(H)	(0.5,0. 7,0. 9)
Very high(VH)	(0.7,0. 9, 1.0)

Table4: Fuzzy linguistic for decision makers rating.

Very poor(VP)	(0, 1,3)
Poor(P)	(1, 3, 5)
Fair(F)	(3, 5, 7)
Good(G)	(5, 7, 9)
Very good(VG)	(7, 9, 10)

As shown in table 3 and 4, all the numbers are positive triangular fuzzy numbers, and in order to retrieve the graded mean integration representation of triangular fuzzy number definition 3 is used:

Definition3. *Given a triangular fuzzy number $\tilde{A}$ = (a, b, c), the graded mean integration representation of triangular fuzzy number $\tilde{A}$ is defined as [12, 13]: P ($\tilde{A}$) =1/6(a+4b+c).*

Definition4. *Let $\tilde{A} = (a_1, a_2, a_3)$ and $\tilde{B} = (b_1, b_2, b_3)$ be two triangular fuzzy numbers. The representation of the addition operation $\oplus$ on triangular fuzzy numbers $\tilde{A}$ and $\tilde{B}$ can be defined as [12, 13]: $P(\tilde{A} \oplus \tilde{B}) = P(\tilde{A}) + P(\tilde{B}) = 1/6\{(a_1+b_1)+4(a_2+b_2)+(a_3+b_3)\}$.*

Definition5. *The canonical representation of the multiplication operation on triangular fuzzy numbers $\tilde{A}$ and $\tilde{B}$ is defined as [12, 13]: $P(\tilde{A} \otimes \tilde{B}) = P(\tilde{A}) \times P(\tilde{B})$.*

In order to reduce the complexity of fuzzy calculations the above definitions are crucial, yielding a crisp number instead of a fuzzy one which eases the comparison of alternatives [6, 14].
By applying Definition 3, the graded mean integration representation of the importance of weights and decision makers rating will be crisp values as table 5 and 6

respectively (based on method used in [15] and *definition 3* mentioned in [13], in which triangular fuzzy numbers range fall into [0, 1].

Table5: Graded mean of weights.

Very low(VL)	0.1167
Low(L)	0.3
Medium(M)	0.5
High(H)	0.7
Very high(VH)	0.8834

Table6: Graded means of decision makers rates.

Very poor(VP)	1.167
Poor(P)	3.000
Fair(F)	5.000
Good(G)	7.000
Very good(VG)	8.834

In this section, the decision matrix of alternatives ratings based on new hybrid TOPSIS with fuzzy triangular linguistic variables will be constitute. The method used here is same as [6, 14, 17, 18] except for determination of positive and negative ideal solutions for fixed cost which is based on method of [5, 15].

Steps are as below:

Step1. *Aggregation of importance of weights.* This step is summarized as table7 and is called the aggregated importance weight $W_{j.}$

Table7: Aggregated weights W_i.

C_1	0.45
C_2	0.6459
C_3	0.6
C_4	0.7417

The final weighted matrix based on criteria (m) and decision maker (n) will be W_j as:

$$\begin{pmatrix} 0.45 & 0 & 0 & 0 \\ 0 & 0.6459 & 0 & 0 \\ 0 & 0 & 0.6 & 0 \\ 0 & 0 & 0 & 0.7417 \end{pmatrix}$$

Step2. *Aggregation of rates assigned by decision makers*. Based on table 2 and 6, result of aggregation of rates based on graded mean integration will be a (4*4) matrix called decision matrix R_{ij} and the final result of operation is:

$$R_{ij} = \begin{pmatrix} 7.917 & 6.459 & 5.954 & 5.001 \\ 6 & 6.917 & 6.0 & 6.459 \\ 6.459 & 5.0 & 5.5 & 5.0 \\ 5.917 & 7.917 & 4.542 & 4.5 \end{pmatrix}$$

Step3. Construction the weighted decision matrix and its normalization.

The decision matrix S_{ij} is a 4*4 matrix as $S_{ji}=W_j \otimes R_{ij}$ in which operation $\otimes$ is as *definition 5*. By application of this operation the complicated fuzzy interval operations on membership functions has converted to crisp arithmetic [6, 15]. The resultant matrix S_{ij} will be:

$$S_{ij} = \begin{pmatrix} 3.5626 & 2.9000 & 2.6815 & 2.250 \\ 3.8754 & 4.4676 & 3.8754 & 4.1718 \\ 3.8754 & 3.000 & 3.3000 & 3.0000 \\ 4.3886 & 5.872 & 3.3688 & 3.3376 \end{pmatrix}$$

Step4. *Embedding fixed cost factor in decision matrix*.

Since our model deal with uncapacitated facility location, usually there is a fix cost in model which is representative of cost of land, construction of buildings or any other fixed cost related to locating a facility [3, 5, 6, 14].

This fix cost assessed by decision makers is not crisp, and is fuzzy number with equal cores for all candidate location here. These fuzzy numbers are:
A_1= (62, 72, 80)
A_2= (65, 72, 81)
A_3= (63, 72, 79)
A_4= (64, 72, 80)

In order to add these numbers to decision matrix, they must be rated [6, 14]. Based on definition and operations in [6, 13, 14], since they are categorized as fixed cost, so their rating will be:

RA_1=0.8699
RA_2=0.861
RA_3=0.8689
RA_4=0.8647

Now the decision matrix R_{ij} will have 5 columns, representing C_1, C_2, C_3, C_4, and C_5.

Step5. *Normalizing of the decision matrix.* In TOPSIS, normalization of decision matrix is accomplished as matrix $V = [v_{ij}]_{m \times n}$ [5], Where:

$$vij=\frac{rij}{\sqrt{\sum_{i=1}^{m}(rij)2}} \qquad (1)$$

By applying (1), decision matrix will convert to normalized matrix V_{ij}, which all the elements are in range [0, 1] as below:

$$\begin{pmatrix} 0.4524 & 0.3421 & 0.4022 & 0.3447 & 0.8699 \\ 0.4922 & 0.5270 & 0.5812 & 0.6391 & 0.8610 \\ 0.4922 & 0.3539 & 0.4948 & 0.4596 & 0.8689 \\ 0.5574 & 0.6927 & 0.5052 & 0.5113 & 0.8647 \end{pmatrix}$$

Step6. *Positive (A^+) and negative (A^-) ideal solution determination*. In positive ideal solution maximum and for negative ideal solution minimum variables of normalized decision matrix for each candidate location will be chosen [5, 6, 14]. The result will be:

(A^+)= (0.5574, 0.6927, 0.5812, 0.6391, 0.861).

(A^-)= (0.4524, 0.3421, 0.4022, 0.3447, 0.8699).

Note: since C_5 is cost and usually firms try to eliminate any costs, even fixed costs [3, 5, 15], here we assume it as negative criteria and based on [5], in positive and negative ideal solution, minimum and maximum value is considered respectively. In [6], it is not considered so, causing deviation of the best alternative opt.

Step7. *Finding distance of each decision variable to ideal solution [5, 6, 14].* By definition, this distance is known in literatures as *Euclidean distance* [3]. The Euclidean distance of a variable to positive ideal solution and negative ideal solution is as table8:

Table8: euclidean distance of each alternative

	d^+	d^-
A_1	0.5027	0.0
A_2	0.1780	0.3931
A3	0.3984	0.1533
A_4	0.1487	0.4153

Step8. *Calculate closeness coefficient of each alternatives.* In order to specify which alternative best suit to decision maker's criteria's, the closeness coefficient is defined as:

$$CC = \frac{(\mathbf{d}-)}{(\mathbf{d}+) + (\mathbf{d}-)} \qquad (2)$$

The closeness coefficient measures how far an alternative is from its best and ideal solution. The best alternative is the one with biggest closeness coefficient. The closeness coefficient for alternatives will be:

CC_{A1}= 0.0
CC_{A2}= 0.6883
CC_{A3}= 0.2778
CC_{A4}= 0.7362

The best alternative to locate remanufacturing plant with specified criteria based on decision maker's fuzzy linguistic ratings is the one with maximum closeness coefficient, which is A_4.

CONCLUSION

Deciding where to locate a new facility in a supply chain is an old problem, but design of a closed loop supply chain is a new concept in supply chain design. Since there are many reasons for remanufacturing, reuse, and recycle of products (3Rs), it seems that locating new facilities to implement these Rs is inevitable. In this paper we use the fuzzy TOPSIS method to determine location of remanufacturing facility and design a closed loop supply chain. Since uncapacitated facility location decisions have a fixed cost in objective function, this concept was considered as fuzzy numbers along with other criteria chosen by decision makers. The fuzzy linguistic method implemented, reduces the complexity of fuzzy operation and enable decision makers to deal with ambiguity factors fast and easily, and determine where to locate new plant based on fuzzy linguistic decision makers rates. Previous researches were on mixed integer linear models to find best place to locate new facility, but these models eliminate uncertainty in parameters such as demand or cost. The future research should include the uncertainty of factors in decision making and to build a mixed integer linear model with hybrid variables. The concept of rough and fuzzy variables can be implemented simultaneously to cope with uncertainty of parameters.

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D4 – Sustainability

D4.1 **Identifying strategic enablers for green supply chain excellence**
Chinho Lin

D4.2 **Sustainable financial products: Spanish society's perceptions about socially responsible investing**
Elena Escrig-Olmedo

D4.3 **The impact of China oil demand on oil price and Russia trading system index**
Chun-Kuang Wu

IDENTIFYING STRATEGIC ENABLERS FOR GREEN SUPPLY CHAIN EXCELLENCE

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ABSTRACT

To modern enterprises of all sizes, designing and improving green supply chains to create value and competitive advantage posits new challenges. Policy makers today, in the pursuit of both economic performance and environmental sustainability, need to adopt Green Supply Chain Management (GSCM) practices to create supply chains' overall value and ensure that environmentally conscious products and processes are well designed and performed. This paper presents a hierarchic framework to aid policy makers in decision making to achieve such a goal. The first focus of this study is on finding agents, required functions, and critical enablers of GSCM to build the hierarchic framework. Five strategic enablers are identified and considered in this work: green purchasing, green manufacturing, green distribution, green marketing, and reverse logistics. The second focus of this work is on prioritizing these five enablers of GSCM. The Fuzzy Analytic Network Process (FANP) is employed to find priority weights. We also empirically illustrate our hierarchic framework's applicability to GSCM problems involving major chemical companies in Taiwan. Our framework enables policy makers to explore the problem context and decide on the strategic direction in value creation and environmental sustainability.

Keywords: Green Supply Chain Management (GSCM), Green Supply Chain Strategy, Fuzzy Analytic Network Process (FANP)

INTRODUCTION

Since the publication of *Competitive Advantage: Creating and Sustaining Superior Performance* Porter (1980), a lot of progress has been made in understanding the managerial, technical, and sociopolitical responses of the firm in an internal/external supply chain setting. Enhancing the efficiency and effectiveness of a value chain, the focal point of Porter's value chain model, has therefore been the hallmark of operations and supply chain management. Today's focus, however, is different. Industry leaders such as HP, Apple, Dell, and Wal-Mart are now seeking broader goals such as protecting the environment and developing communities. Green Supply Chain Management (GSCM) today, as a result of this new focus, seems to play a significant role in this new world of sustainable development (Srivastava, 2007; Chung and Wee, 2010; Park, et al., 2010).

Srivastava (2008, p.536) defines GSCM as "integrating environmental thinking into supply chain management including product design, material sourcing and selection, manufacturing processes, delivery of the final product to the consumers as well as end-of-life management of the product after its useful life." Thus, several key challenges centered around reducing wastes, conserving resources, and increasing throughputs and supply chains' overall value exist. Despite this understanding and development in the field of GSCM, many published studies, however, focused either on the performance of green operations (e.g. Zhu and Sarkis, 2004; Zhou, 2009) or on GSCM from the perspective of green design (e.g. Srivastava, 2007; Chung and Wee, 2010; Park, et al., 2010). Srivastava (2007), for example, pointed out that green design consists of two fields: life cycle analysis (LCA) and environmentally conscious design (ECD). The former is normally used to help policy makers quantify the environmental impact of supplied goods and services. The latter allows supply chains to minimize the environmental impact of products and to turn waste into profitable products (Zhang, et al., 1997). To respond positively to such pressures, achieve both supply chain value and environmental sustainability simultaneously, and be able to compete in today's environmentally conscious market, modern enterprises need to develop their own strategies to enable general applications of GSCM and Porter's value chain model. Adopting the GSCM way and a holistic view based on Porter's model at the same time, however, is not an easy task. To overcome this, we ponder the following research questions in this study:

- What specific agents, functions, and strategic enablers (i.e. content variables) should policy makers consider in the context of green supply chains?
- How can policy makers measure the potential contributions of green and valuable supply chain strategies in the Asia-Pacific region?

The answers to the first question are derived from literature review. For the purpose of our scientific inquiry in the first phase of this study, we propose a hierarchic framework called green and valuable supply chain. This model serves as a basis for the follow-up inquiry. The answers to the second question are based on the operational procedure of Fuzzy Analytic Network Process (FANP). The use of FANP helps to capture the imprecision in human judgment and set priorities for designing and improving green supply networks. To illustrate our scientific inquiry process and also to identify the key strategic enablers for designing and improving green supply chains, major chemical companies in Taiwan were contacted to

participate in this project. Focus on our hierarchic framework and operational procedures can help firms improve their green supply chain overall performance.

THEORETICAL DEVELOPMENT

In order to develop our hierarchic framework to aid policy makers in decision making, we look to the existing literature. Three fields that arise from the literature are: Supply Chain Management (SCM), Porter's value chain model, and Green Supply Chain management (GSCM). We shall briefly discuss them here.

Supply chain management

The five basic entities of typical supply networks are suppliers, manufacturers, distributors, retailers, and customers (Fiala, 2005). These five entities can enhance the overall performance of the entire supply chain via cooperation, collaboration or alliance (Fiala, 2005). They are considered to be agents in our proposed hierarchic framework. Supply Chain Management (SCM) is normally employed to develop such capabilities and capacities. Madu and Kuei (2004) define SCM with two simple equations where each equation represents the letters that make up SCM. The definition is as follows:

Supply Chain = A production-distribution network; and
Management = Enabling conditions for integrity, integration, process optimization, operational efficiency, continuous improvement, and sustainable competitive capabilities.

Value can be added at every stage of the product and service realization. The use of SCM ensures that the best value is obtained for each product or service (Errasti, et al., 2009; Wei and Wang, 2010; Yang, et al., 2011).

Value chain model

Value chains exist for the purpose of creating value and competitive advantage (Porter, 1985). A typical value chain involves five primary activities: inbound logistics, operations, outbound logistics, marketing, and services. It starts with inbound logistics and ends with the service function. They are considered to be functions in our proposed hierarchic framework. Supporting activities such as procurement, technology, human resource management, and firm infrastructure also play important roles in customer satisfaction. According to Porter (1985), these networked organizational units need to work together to reduce costs, minimize transit time, improve quality and operational efficiency, and improve customer service. The value chain model has been widely used as a means for improving the overall value of the entire chain in question (Bhattacharya, et al., 2010; Ehret and Cooke, 2010; Jin and Zailani, 2010).

Green supply chain management

While both Porter's value chain model and SCM have brought significant benefits, moving on, modern enterprises have also ranked the environment one of the major challenges facing

businesses in the future (Errasti, et al., 2009; Bhattacharya, et al., 2010; Jin and Zailani, 2010). Zhu, et al. (2008, p.578) defines Green Supply Chain Management (GSCM) as "a recent and important inter- and intra-organizational set of environmental practices useful for logistics management." The organizational context in such a supply chain setting includes: green purchasing, green manufacturing, green distribution, green marketing, and reverse logistics (Li and Cai, 2008; Srivastava, 2008; Zhou, 2009; Wooi and Zailani, 2010). They are regarded as enablers (i.e. content variables) in our proposed hierarchic framework. In the world of sustainable development, green supply chain strategies and practices are considered by modern enterprises to be a new source of corporate competitiveness (Rao and Holt, 2005; Menzel, et al., 2010; Thun and Müller, 2010).

To create a capable green supply chain and leverage the benefits of Porter's value chain concept, Supply Chain management (SCM), and Green Supply Chain Management (GSCM), modern enterprises today need to set priorities among supply-chain-wide green and valuable supply chain management programs and projects. A strategic framework thus needs to be developed and promoted to enable the consideration of both economic performance and environmental protection. Such a framework will be described in the next section.

THE BIRTH OF GREEN AND VALUABLE SUPPLY CHAINS

In order to accomplish the first goal of this study, a hierarchic framework is introduced. As shown in Figure 1, our hierarchic framework is a complex system which effectively connects major components identified from (1) Supply Chain Management, (2) Porter's value chain model, and (3) Green Supply Chain Management. This conceptual model is referred to as a green and valuable supply chain in this study.

As suggested by our hierarchic framework, the best chance of meeting the value creation and environmental protection goals simultaneously is to formulate green and valuable supply chain strategies to (1) know the role of specific agents, (2) understand required functions, and (3) realize the full potential of GSCM. To meet such a challenge, as can be seen in Figure 1, the first path centers around primary channel partners along a typical supply chain. As discussed in the previous section, policy makers need to address specific concerns of suppliers, manufacturers, distributors, retailers, and customers. Channel partners are the premise of every enterprise's existence. This model can then be extended to address the five primary functions suggested by Porter (1985): inbound logistics, operations, outbound logistics, marketing, and services. This extended model shows the roles policy makers should play to set the stage for the implementation of green and valuable supply chain systems. With the stage set, how do modern enterprises then achieve value and environmental sustainability simultaneously? To answer this, it is most important for policy makers to consider another path for both policy deployment and strategy formulation. It is evident from Figure 1 that the GSCM way can embrace the new focus on green and valuable supply chain. Our research has identified five strategic enablers (i.e. content variables) influencing the effectiveness of GSCM. They are: green purchasing, green manufacturing, green distribution, green marketing, and reverse logistics. As can be seen at the bottom of Figure 1, each of the content variables that are of interest to the modern enterprises is respectively evaluated. For example, green purchasing consists of three

elements: non-toxic, reusable, and recyclable. The ultimate aim here is to ensure that the development of any of the content variables will achieve value and environmental sustainability simultaneously.

This framework can assist policy makers in managing value creation and environmental issues simultaneously, designing a complex green and valuable supply chain, spotting strategic problems early, and developing plans to better serve the channel partners. However, a strategic analysis is also needed to enable policy makers to identify the most critical GSCM content variables that will ultimately influence the successful development of green and valuable supply chain systems. The Fuzzy Analytic Network Process (FANP) is thus employed to accomplish the second goal of this study. This operational procedure will be illustrated in the next two sections.

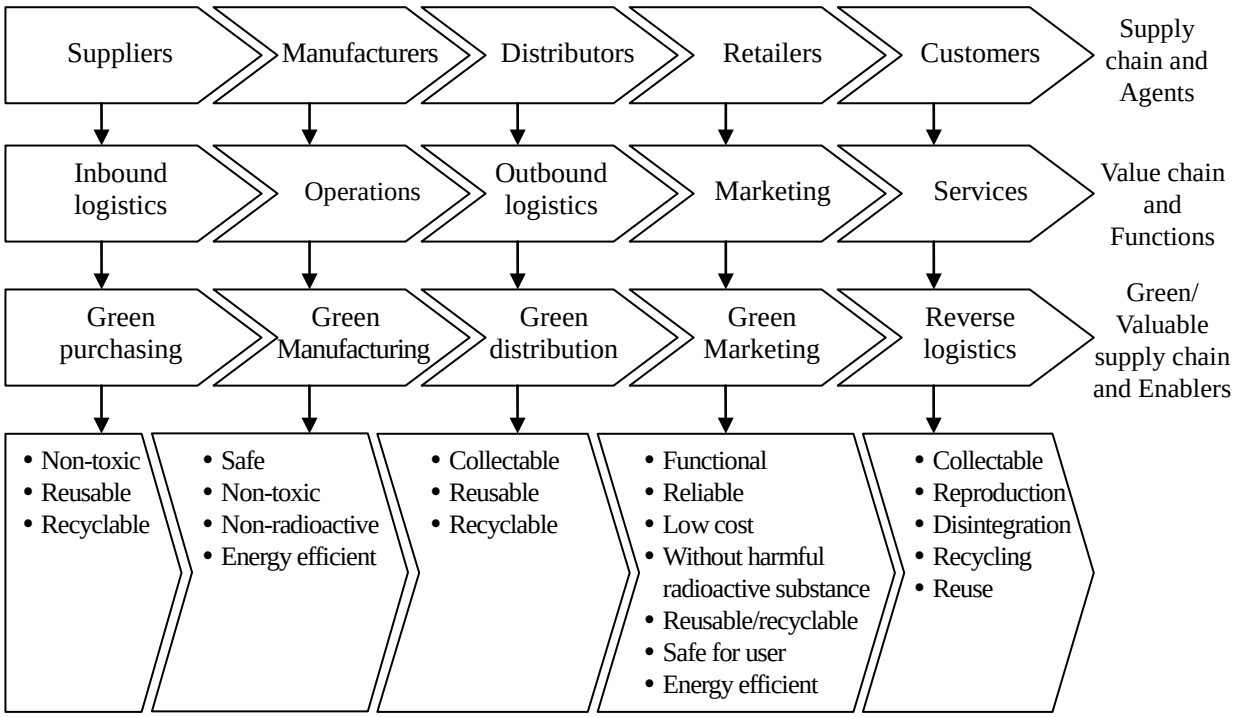

Figure 1 : Dimensions of Green and Valuable Supply Chains.

MODELING

The second part of this study applies a Fuzzy Analytic Network Process (FANP) in the context of green and valuable supply chains. To facilitate this process, we need to first develop the ANP-based decision hierarchy. In this section, the Analytic Network Process (ANP) modeling approach and the operational procedure of FANP are briefly discussed.

The ANP-based decision hierarchy

As noted by Saaty (2004, p.129), the Analytic Network Process (ANP) "provides a general framework to deal with decisions without making assumptions about the independence of

higher-level elements from lower level elements and about the independence of the elements within a level as in a hierarchy." Sarkis (2003, p.408) also pointed out that the ANP modeling approach allows policy makers the flexibility to "identify and incorporate major interdependencies among many factors and clusters in a "dynamic" fashion." In other words, the modeling of dependencies among elements of the problem is possible. Also, a complex problem can be broken down into a decision hierarchy for further analysis. By referring to Figure 1, dimensions of green and valuable supply chains, a decision hierarchy is developed here. As shown in Figure 2, the top-most component in the ANP-based decision hierarchy is green and valuable supply chain. This is further decomposed into enablers (i.e. content variables) and sub-components (i.e. sub-criteria). Five key enablers are presented in Figure 2. They are: green purchasing, green manufacturing, green distribution, green marketing, and reverse logistics. In the case of green purchasing, for example, three sub-components are considered, namely, non-toxic, reusable, and recyclable. As shown in Figure 2, we also propose that no interrelationships exist at the upper component levels. Interdependencies are considered only at the sub-component level. Interviews with corporate executives need to be conducted to test our proposed model.

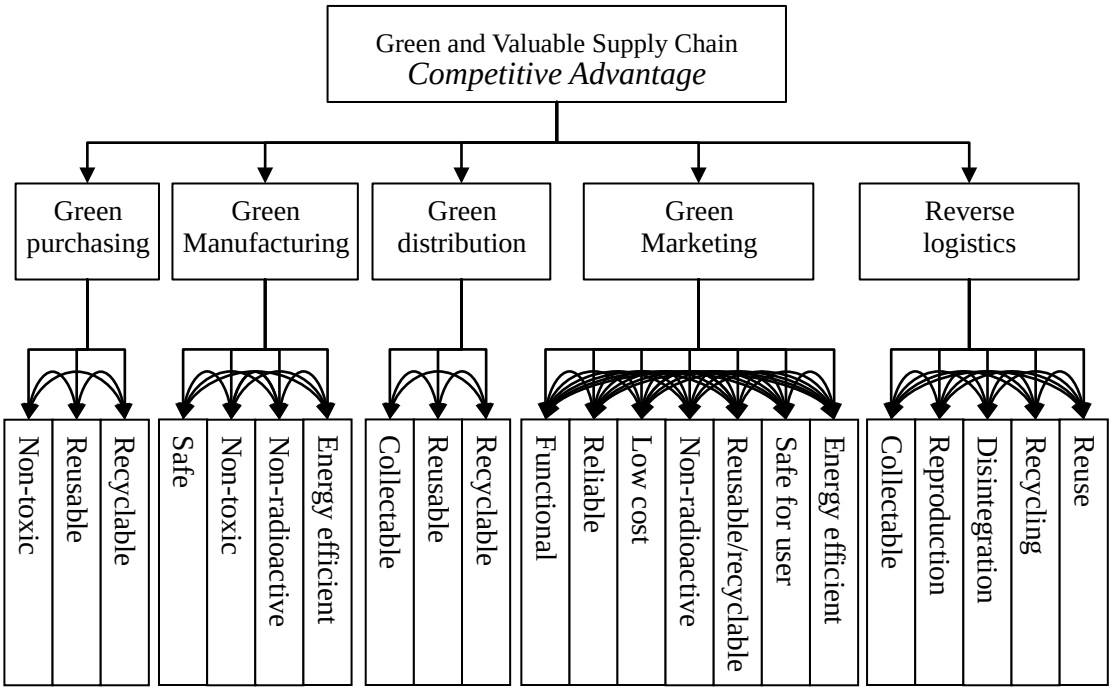

Figure 2: Decision Hierarchy.

The fuzzy-based ANP procedure

To prioritize enablers (i.e. content variables) and sub-components (i.e. sub-criteria) presented in the decision hierarchy (see Figure 2), the general approach of the Fuzzy-based ANP data collection and Super-matrix analysis procedure described by Ayag and Ozdemir (2009) needs to be followed. The approach consisting of three steps is shown below:

Step 1: Prepare pairwise comparison matrices based on the proposed decision hierarchy

(see Figure 2) and collect field data. A nine-point fundamental scale is used in these pairwise comparisons. Appendix A shows the comparison matrix designed for the pairwise comparison at the enabler level.

Step 2: Record data by using fuzzy scales, defuzzify the fuzzy values, and convert group defuzzified values to a single value (if group inputs are available).
The process is described as follows. First, we need to transform the linguistic terms into triangular fuzzy numbers (see Appendix B). The triangular fuzzy numbers are defined as $\tilde{M} = (l, m, u)$, where $l \le m \le u$.

Following are the triangular fuzzy functions:

$$u_M(x) = \begin{cases} 0 & x < l \\ x - l/m - l & l \le x \le m \\ u - x/u - m & m \le x \le u \\ 0 & x > u \end{cases}$$

According to the characteristics of triangular fuzzy numbers, we can calculate the fuzzy values. For instance, two triangular fuzzy numbers $\tilde{M} = (l_1, m_1, u_1)$ and $\tilde{N} = (l_2, m_2, u_2)$ can be calculated by using the following equations:

$$\tilde{M} \oplus \tilde{N} = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
$$\tilde{M} \Theta \tilde{N} = (l_1 - l_2, m_1 - m_2, u_1 - u_2)$$
$$\tilde{M} \otimes \tilde{N} = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2)$$
$$\tilde{M} / \tilde{N} = (l_1 / l_2, m_1 / m_2, u_1 / u_2)$$

In such a study, if we need to deal with judgments from a group of experts, as noted by Condon, et al. (2003), we can use one of the following approaches to handle group inputs: the center of gravity method, the center of maxime (CM) method, and the α-cut method. Klir and Yuan (2005, pp.336-338) also reported that the resulting number must "summarize the elastic constraint imposed on possible values of the output variable by the fuzzy set." In this study, we therefore select the CM method. The defuzzified value, as a result, is defined as the average of the smallest value and the largest value in a fuzzy interval.

Step 3: Obtain the initial weights for each pairwise comparison matrix by using M.S. Excel, construct the initial Super-matrix, and use SuperDecisions software (http://www.superdecisions.com/) to obtain the final weights for each survey item.

The ultimate goal of this operational procedure is to identify survey items' local and global priorities. Appendix C provides a schematic representation of the decision hierarchy we proposed to conduct the ANP-based analysis in the SuperDecisions modeling environment. This operational procedure will be illustrated with our follow-up empirical work.

EMPIRICAL ASSESSMENT

Two tasks will be conducted to achieve the second goal outlined in this study: (1) pretesting the conceptual model, and (2) conducting case studies.

Pretesting the conceptual model

We will interview industry experts and corporate executives from companies in the Chemical Industry in Taiwan to confirm that the sub-criteria of our proposed ANP-based conceptual model are suitable. Based on the results of our interview, if needed, we will revise our decision hierarchy. Figure 3 depicts our pretest procedure. This goal can be reached in a reasonably short time frame.

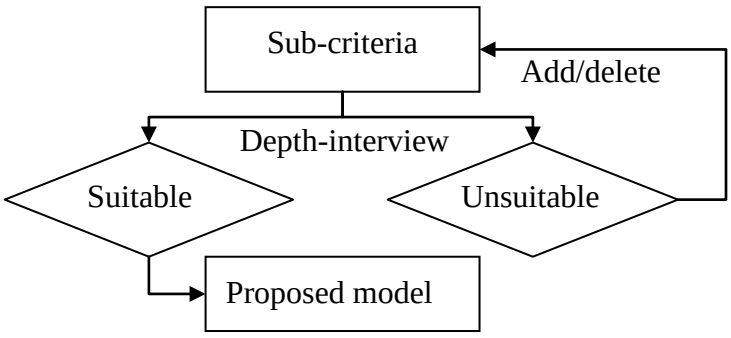

Figure 3: Pretest Procedure.

Case study

When our proposed model is confirmed with industry experts and corporate executives from major chemical companies in Taiwan, we will test our model by using the case study approach. This procedure is outlined as follows: We will interview top-level managers in company A (a major chemical company in Taiwan) and then contact one of its suppliers (company B) and one of its customers (company C). At the conclusion of this interview, we will send questionnaires to ten practicing managers from company A randomly. We will also contact companies B and C for the purpose of data collection. This procedure is shown in Figure 4. Survey items' local and global priorities will be obtained by following the FANP approach. This goal can be reached in two to three months.

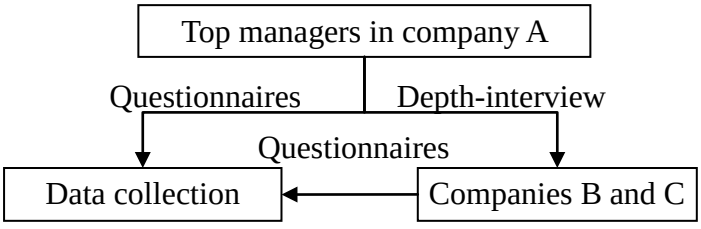

Figure 4: Scientific Inquiry Procedure.

SUMMARY AND EXPECTED RESULTS

The main contribution of the first part of this work is to build a hierarchic framework to help policy makers make better decisions in the context of green and valuable supply chains. The ultimate goal is to achieve value and environmental sustainability simultaneously. The general hierarchic framework and strategic analysis procedures shown in this paper can offer good guidance in effectively designing and improving green supply networks. In practice, however, it is also necessary to consider the entire operational conditions of green and valuable supply chains from different agents' perspectives when developing green supply chain strategies. To this effect, empirical works are needed. The current work, however, is a report of preliminary findings and our decision hierarchy. Our research team will continue our ongoing investigation of green and valuable supply chains. Through empirical studies, we expect to (1) obtain a concept map to assist policy makers in the decision making process, (2) find survey items' local and global priorities (see Figure 5), and (3) further identify implications for both practice and theory. It is our belief that the second goal of this work can be reached in a reasonably time frame.

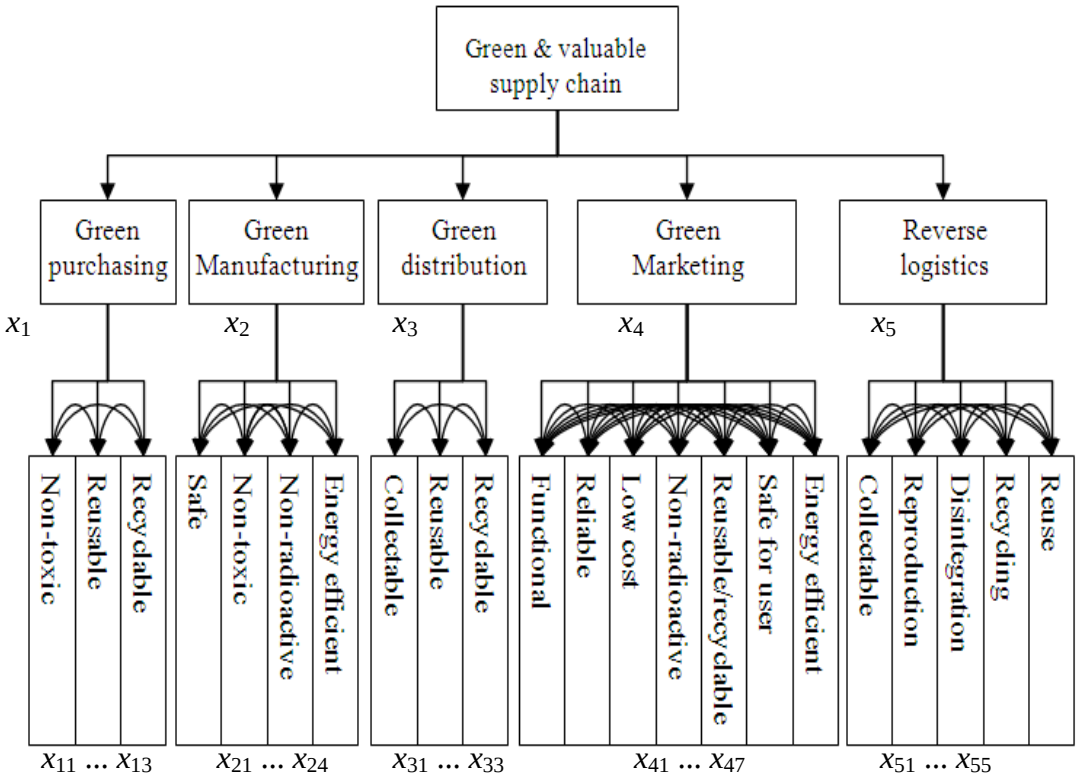

Figure 5: Expected Results.

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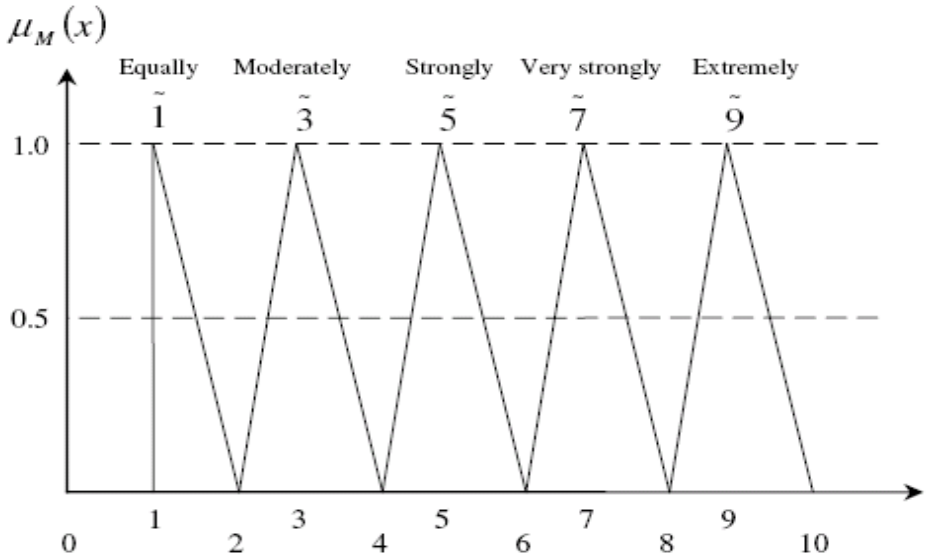
Appendix A Comparison Matrix

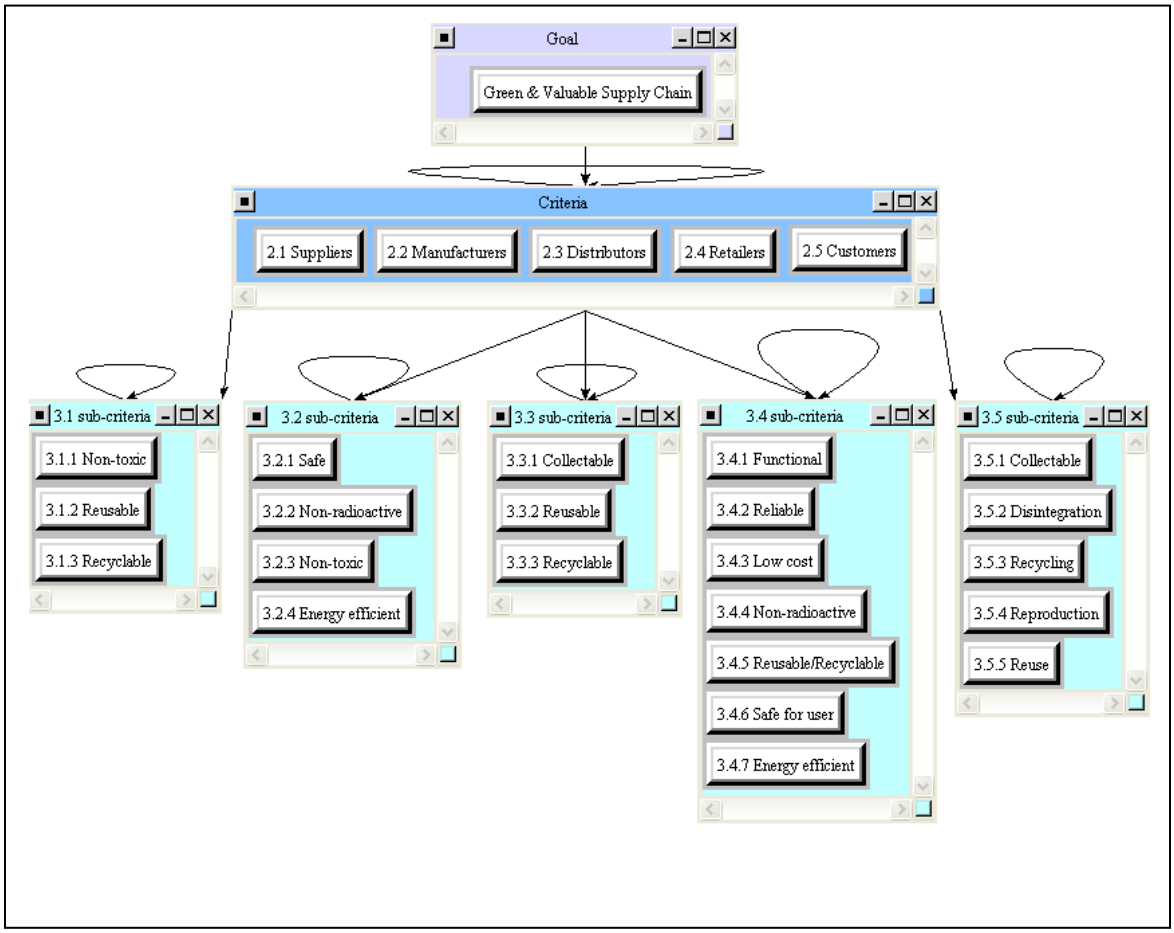
With respect to Green and Valuable Supply Chain, please make your judgments about the relative preference/importance of the item i (e.g. green purchasing) and item j (e.g. green manufacturing

	Extremely more important	Very strongly more important	Strongly more important	Moderately more important	Equally important	Moderately more important	Strongly more important	Very strongly more important	Extremely more important	
Green purchasing										Green manufacturing
Green purchasing										Green distribution
Green purchasing										Green marketing
Green purchasing										Reverse logistics

Appendix B Intensity of Importance (Ayag and Ozdemir, 2009)



Appendix C Hierarchy of Enablers with Elements



SUSTAINABLE FINANCIAL PRODUCTS: SPANISH SOCIETY'S PERCEPTIONS ABOUT SOCIALLY RESPONSIBLE INVESTING*

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ABSTRACT

Socially responsible investing (SRI) is the financial investment process that takes into account social, environmental, and corporate governance impacts and/or investment in the community – as well as shareholder activism. SRI investors encourage corporations to improve practices on environmental, social, and governance issues.

The debate surrounding the financial needs of investors and the impact on society of investment is considered to be a very important research topic due to the growth of socially responsible financial markets. The main objective of this research is to study the perception of the Spanish public about SRI criteria and real-life investment needs – and identify the most relevant sustainable financial products.

To examine the Spanish perception of *SRI, we conducted a field survey among 525 Spanish citizens between April 2010 and November 2010.*

The results show that SRI is in an early stage and Spanish investors need more exact information regarding social, environmental, and governance criteria in order to invest in socially responsible companies and products.

Keywords: socially responsible investing (SRI), SRI criteria, sustainability, sustainable financial products.

INTRODUCTION

SRI is the financial investment process that takes into account social, environmental and corporate governance impacts and/or investment in the community – as well as shareholder activism (SIF, 2009). Socially responsible investment decisions have been studied in the economic and financial literature in recent years from various perspectives (Anand and Cowton, 1993; Williams, 2007) that have sought to establish the determinants of these investment choices.

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The objective of this article is to study the Spanish perception of SRI criteria and real-life investment needs. A questionnaire was developed to obtain the necessary information.

Through the media it is possible to see a reinterpretation of financial investment criteria and a more in-depth analysis and assessment of the environmental, social, and ethical behaviour of companies (Nieto and Fernández, 2004).

In recent years, SRI has become a key factor for institutional investors and is especially relevant for individuals. The European SRI market has increased from €2.7 trillion in 2007 to €5 trillion at the end of 2009; a growth of about 87% over two years (Eurosif, 2010). This growth can be partly attributed to changes in regulation regarding the disclosure of social, environmental, and ethical information by pension funds and listed companies (Renneboog, et al., 2008).

SRI is considered a very important topic in research due to the growth of financial markets. The inclusion of environmental criteria in the investment decisions of investors is making corporate behaviour more sustainable (Brammer and Pavelin, 2005). Firms and investors recognise that investing in accordance with the principles of sustainability can create long-term value (Bebbington, 2001). Moreover, investor behaviour has become one of the most important drivers encouraging Western governments to introduce regulatory initiatives to stimulate SRI.

This paper is structured as follows: the introduction is followed by a brief explanation of the Spanish SRI market. Subsequently, we show the methodology used and the results obtained. The final section provides the main conclusions.

SOCIALLY RESPONSIBLE INVESTMENT MARKET IN SPAIN

SRI is interpreted differently in different geographical areas, with distinct characteristics linked to the particularities of each financial market and the legal and cultural framework of each country (Cañal et al., 2008).

SRI was first discussed in Spain in the late 1990s when the first socially responsible investment funds (SR fund) were launched. Specifically, the first Spanish-based SR fund was launched in 1997 – the *Iber Fondo 2020 Internacional* – which included companies whose investments were aligned with the views of the Catholic Church. In the same year, the *Arco Iris de Ahorro Corporación* launched an investment fund for environmentally friendly technology companies. Two years later in 1999 several more SR funds appeared on the Spanish market.

The main feature of the SRI market in Spain is the difference between the institutional market, the core market for SRI in Spain, and the retail market. According to a report published by the *Observatorio de Inversión Socialmente Responsable* (2010) assets invested in SRI in Spain at December 31 2009 totalled €14,053,875,000 (10% more than 2008); and the total number of investors with SR criteria was 814,766 (up 0.229% on the previous year). Some €13,919,368,000 of the total assets invested in SRI (representing 99% of total SRI market) was invested in the institutional market and primarily consisting of occupational

pension funds. Assets invested on the retail market totalled €134,507,000, or 1% of the total. This fact emphasises the importance of institutional SR investors in Spain, especially with respect to occupational pension funds, despite the absence of legislative measures to encourage SRI.

In November 1999, the Spanish Association of Investment and Pension Funds (INVERCO) issued guidance on the use by mutual funds of the terms 'ethical', 'ecological' and any other term regarding social responsibility. This guidance was approved by the Spanish Securities and Investments Board (CNMV) and its objective was to define the criteria that investment funds must meet to include these terms in their names. To standardise this situation and give greater transparency to ethical fund policies, the Spanish Standardisation and Certification Association (AENOR) published in 2002 a standard entitled: 'Requirements for Ethical and Socially Responsible Financial Instruments' (PNE 165001 EX) that specifies the requirements for ethical and socially responsible financial instruments created and sold by any organisation legally permitted to do so (Muñoz, et al., 2004). Regulation 31 of the Sustainable Economy Act -BOE, 5/03/2011- (*regulations for the dissemination of information on pension fund investment policies)* states that further regulations will be issued regarding the dissemination of information on social, environmental, and good governance criteria in the investment policy of pension funds.

In addition to SRI, other mechanisms are available for investors wishing to implement sustainability in their decision making processes: sustainability rating agencies and sustainability indices. Sustainability indices facilitate the selection of investments – but restrict the investor's choice of socially responsible criteria.

The first Spanish sustainability stock index – the 'FTSE4GoodIBEX' – was launched in 2008 and includes medium and large companies from the Spanish stock exchange. The index is part of the FTSE4Good family of indices and follows an established inclusion and exclusion criteria.

METHODOLOGY AND SAMPLE

The survey

To examine the public perception about SRI criteria and the real-life needs of investors we conducted a user study. The multidisciplinary method employed uses several research techniques to analyse the various aspects and features of the relationship between the information and the user (Martin, 2007). Specifically, we have designed a self-administered survey because: (1) this approach enables the study of a large number of both objective and subjective aspects that are not directly observable; (2) information is obtained from a wide range of people in different geographical areas and within a relatively short period of time; (3) the approach facilitates comparison between responses; (4) the results can be generalised, etc. The disadvantages include the relatively low response rate and absence of personal contact with the respondents (Martin, 2007).

525 individuals were surveyed from around Spain between April 2010 and November 2010. However, the final sample was reduced to 66% of the valid responses. This reduction was

made for two reasons: firstly, a lack of awareness of the product by many respondents – this phenomenon could be the result of the poor development of SRI in Spain. Secondly, as the survey was self-administered, this sometimes led to multiple answers being given to question where just one answer was required – and thereby preventing subsequent data analysis.

Research using small sample sizes is not uncommon in this field of study, for example: Bigné et al., (2005) studied the perception of CSR (corporate social responsibility) in four nations with sample sizes smaller than of 155 subjects per nation (418 total responses); Anand and Cowton (1993) explored socially responsible investor behaviour with a sample of 125 observations from the EIRIS database; Lewis and Webley (1994) observed that the majority of investors showed an attitude revealing a positive predisposition to make social and environmental investments using a questionnaire given to 100 investors; McLahan and Gardner (2004) provided a comparative examination of 55 conventional and 54 socially responsible investors, with the aim of identifying the factors that lead investors to choose socially responsible investment products.

The questionnaire for the study was made up of 28 items and included five sections: 1) general questions; 2) questions related to Spanish investors; 3) questions related to SRI; 4) questions related to socially responsible funds; and 5) questions related to sustainability indices and sustainability rating agencies. Various references were used in designing the questionnaire – such as those issued by Balaguer et al. (2008) to managers; the previously cited Bigné, et al., (2005); or *Economistas sin Fronteras* and UNED (2007).

The sample

The results for the profile of socially responsible investors are not unanimous. However, many studies show that socially responsible investors tend to be university-educated women (Tippet and Leung, 2001; Schueth, 2003; Williams 2007); university-educated men (Haigh, 2008); in late middle-age (Lewis and McKenzie, 2000 a, b, ESF and UNED, 2007); and with an above-average income (Lewis and McKenzie, 2000 a, b, Haigh, 2008). This lack of consensus may be due to the size of the samples, the use of differing methodologies, differing survey designs, and the varying nature of the nations studied, etc.

Coinciding with the literature, in our study socially responsible investors are mostly women, middle-aged, university-educated, and with average incomes – and students (Table 1). This last feature, which differs from results in the literature, can be explained by the fact that 19% of our sample is made of post-graduate students of corporate social responsibility and advanced finance.

Table 1: Profile of sample rates.

Variables		Total sample (N=345)	Socially responsible consumer[1]
Sex	Male	53.3%	4.9% of all men
	Woman	46.7%	6.8% of all women
Age	18-24 years	9.9%	5.8% of total
	25-34 years	39.7%	6.6% of total
	35-45 years	27.2%	5.3% of total
	45-54 years	8.7%	3.4% of total
	55-64 years	9.9%	8.8% of total
	65 or older	4.6%	0
Education	No education	0.3%	0
	Primary school	3.8%	7.6% with no education
	Secondary school	18.8%	4.6% secondary school
	Degree	16.8%	8.6% with degree
	Post-graduate	60.3%	53.4% with graduate studies
Occupation	Student	16.5%	8.8% of total students
	Working	69%	4.6% of total workforce
	Homemaker	2.7%	0
	Retired	9.6%	12.1% of total pensioners
	Unemployed	2.3%	0
Family household income	€ 0-1000	7.8%	7.4% of total
	€ 1,001 € 1,500	10.7%	16.2% of total
	€ 1,501 € 2,000	15.4%	9.4% of total
	€ 2,001 € 2,500	18.3%	1.6% of total
	€ Over 2,500	47.8%	3.6% of total
Percentage of income saved	0-10%	34.5	6.7% of total
	10% -30%	37.7%	6.9% of total
	30% -50%	18.5%	3.1% of total
	50% -70%	7%	4.2% of total
	Over 70%	2.3%	0%

RESULTS

The main results of the study are presented below. Firstly, the data is statistically analysed by applying percentages, and secondly, the possible relationships between the variables are explored.

Statistical analysis

Socially responsible investing

The decision-making process of a socially responsible consumer is more complex than the process for consumers of traditional financial products. This is because social and environmental criteria are sometimes more important than financial criteria (Cañal et al., 2008).

[1] Any individual buying a socially responsible financial product is considered to be a socially responsible consumer.

Table 2: Results of questions on SRI.

1. Have you heard of SRI?			
	YES	NO	No answer
N=345	54.2%	44.3%	1.5%
N=20	100%	0%	0%

2. Have you bought a socially responsible financial product?			
	YES	NO	No answer
N=345	5.8%	87.2%	7%
N=20	100%	0%	0%

3. Which socially responsible financial product have you bought?						
	SRI	Bonds and other SR loans	Guarantee funds	Funds for micro-credits	SR cheque and savings accounts	Other
N=345	1.4%	0.9%	0.6%	0.3%	2.3%	1.6%
N=20	25%	15%	10%	5%	40%	20%

4. Why have you chosen, or would choose, a financial product that includes social and environmental variables?						
	High returns	Security of investing in sustainable products	Advice from bank	Ethical or religious reasons	Social pressure for more responsible behaviour	Other
N=345	28.1%	39.7%	7%	23.3%	5.5%	14.8%
N=20	10%	40%	25%	20%	5%	15%

5. Why have you not chosen, or would not choose, a financial product that incorporates social and environmental variables?						
	Low returns	Doubts about relationship between ethics and returns	Failure to publicise the existence of SR products	Lack of support or endorsement by the state	Charity and donation	Other
N=345	10.7%	18.3%	50.4%	6.6%	5.5%	17.1%
N=20	10%	20%	45%	20%	0%	5%

6. Do you know what ethical banking means?			
	YES	NO	No answer
N=345	31.3%	65.2%	3.5%
N=20	70%	30%	0%

7. Have you heard of any of these ethical banks?						
	Triodos Bank	Citizens Bank of Canada	Cooperativa de crédito Oiko Credit	Southshore Bank	Banca Ética Italiana	Other
N=345	19.4%	6.7%	1.7%	2.3%	3.2%	6.7%
N=20	40%	20%	15%	10%	15%	15%

SRI is at an early stage in Spain and for this reason just 54.2% of the sample recognise the term SRI – while 45.8% do not recognise the term.

Only 5.8% of the total sample has ever purchased a socially responsible financial product. The most frequently purchased products are SR current account and savings deposits (2.3% of the sample and 40% of SR investors). The lack of information about the existence of these products seems to be the most common cause for non-purchase (54.4% of the sample and 45% of SR investors). While the security implied in investing in sustainable products is the main reason for purchasing a SR financial product (39.7% of the sample and 40% of SR investors).

Some 31.3% of the respondents had heard of ethical banking and Triodos Bank was the best known ethical bank (19.4% of the sample and 40% of SR investors). Triodos Bank is the European benchmark for ethical banking with clients in the Netherlands, United Kingdom, Belgium, Germany, and Spain since 2004. It has offices in Madrid, Barcelona, Seville, Valladolid, Valencia, Zaragoza, and the Basque country.

SRI funds

The rapid growth of socially responsible mutual funds is certainly linked to the increased level of interest in socially responsible investing observed in recent years and SRI mutual funds are probably the most prominent financial instrument in the field of ethical finance (Bassso and Funari, 2010).

Table 3: Results of questions about SRI Funds.

8. Have you received information about SR investing?			
	YES	NO	No answer
N=345	12.8%	85.2%	2%
N=20	70%	30%	0%

9. If you were to invest in an SR product what would you value most?				
	Returns	Ethical aspects	Social aspects	Environmental aspects
N=345	55.1%	15.9%	22.6%	6.4%
N=20	35%	20%	25%	20%

10. What is the most valued or positive criterion for you when deciding to invest in SRI?					
	N=345	N=20		N=345	N=20
Equal opportunities	7%	10%	Pollution control	4.3%	5%
Recycling	0.6%	0%	Workplace safety	4.3%	15%
Conserve energy and natural resources	16.5%	20%	Training help	3.5%	10%
Information transparency	21.7%	5%	Corporate investment	0.9%	5%
Social solidarity	31.6%	25%	Others	9.6%	5%

11. What is the most excluding or negative criterion when deciding to invest in SRI?					
	N=345	N=20		N=345	N=20
Gambling-related activities	0.6%	0%	Nuclear production	2.3%	5%
Activities relating to tobacco and alcohol	1.2%	5%	Activities that abuse the environment	5.5%	5%
Practices related to embryo research	0.6%	0%	Activities related to pornography	2.9%	5%
Abortion practices	7.8%	0%	Animal testing	1.4%	5%
Activities that abuse and human and labour rights	36.5%	35%	Support for repressive or dictatorial regimes	13.9%	20%
Lack of transparency in business practices	12.2%	0%	Genetic manipulation	1.2%	0%
Activities related to armaments	7.5%	10%	Others	6.4%	10%

12. In your opinion, when compared with traditional investment funds, SRI is:					
	Riskier	A little riskier	Similarly risky	A little less risky	Safer
N=345	6.4%	11.6%	62%	11.3%	8.7%
N=20	10%	10%	50%	15%	15%

13. In your opinion, when comparing SR in the long run with traditional investment funds, SR offers:					
	Much better returns	Better returns	Similar returns	Lower returns	Much lower returns
N=345	1.2%	7.8%	50.4%	35.4%	5.2%
N=20	0%	10%	50%	35%	5%

14. Do you recognise any of the ethical, environmental, and other SR investment funds offered in Spain?					
	N=345	N=20		N=345	N=20
Santander Central Hispano Responsabilidad FIM	8.4%	25%	BBVA Solidaridad FIM	9.3%	30%
Santander Central Hispano Solidaridad FIM	7%	25%	DWS Ecoinvest FIM del Deutsche Bank	1.4%	15%
BNP Fondo de Solidaridad FIM de la BNP	2%	5%	Other	10.1%	25%

One of the market problems is that Spanish fund managers have not developed appropriate strategies for publicising SR funds – and specifically in the financial sector (IPES, 2002). Less than 12.8% of the sample had received information about investing in SR funds.

Reviewers positively evaluated SR products for profitability (55.1%), followed by social aspects (22.6% of the sample), ethical aspects (15.9%), and environmental aspects (6.4% of the sample) (Table 3).

SRI mutual funds apply a combination of various types of screens: negative screens and positive screens. The negative screens consist of negative (exclusion) criteria that exclude certain investments; while positive screens identify those companies with best behaviours. The use of positive screens is often combined with a 'best in class' approach.
There is no consensus in the literature regarding the social aspects that most concern investors (Tippet and Leung, 2001). These aspects vary depending on the legal framework (Cañal et al., 2008) as well as the cultural and social issues in each country (Katz et al., 2001; Sirmon and Lane, 2004).

The exclusion criterion most valued by respondents are activities that abuse human and labour rights (36.5% of the sample and 35% of SR investors); while the least valued exclusion criteria are gambling-related activities and practices related to embryo research (0.6%) (Table 3).

The most highly valued positive criterion for most respondents was a commitment to social solidarity (31.6% of the sample and 25% of SR investors); and the least valued was recycling (0.6% of the sample).

Another major problem in the Spanish SRI market is that many investors are unaware that the returns on SR are the same as with any other fund in the same category, given that the management approach is the same. Some 40.6% of the respondents believe that financial returns on SR are less than traditional investment funds. In terms of risk, 18% of respondents believe that these funds are riskier than traditional funds.
Most empirical results discussed in the literature suggest that SRI mutual funds produce better or similar returns to other funds (Statman, 2000; Geczy, et al., 2006, Bauer et al. 2006, 2007). However, some empirical results support the opposite conclusion (Chang and Witte, 2010).

The best known SR funds are managed and marketed by the two largest Spanish banks (Santander and BBVA) (Table 3).

Sustainability rating agencies and sustainability indices

Sustainability indices, in the same way as traditional stock market indices, are indicators of the price trends of the most representative shares in a stock market. However, in this case, the market is limited to socially responsible companies. These indices are also used as benchmarks in the management of socially responsible portfolios (Fernández and Muñoz, 2009). While these indices help investors choose investments, they also restrict the application of an investor's own criteria regarding social responsibility.

Sustainability rating agencies are the link between stakeholders and companies (Schäfer, 2005). It is clear that these agencies are growing due to two key factors: the expansion of the securities markets (resulting from the rapid transformation from bank-based to market-

based financial systems); and the growth of regulation (Ferri and Liu, 2005) regarding the disclosure of social, environmental, and corporate governance information.

Sustainability rating agencies study businesses and use their own research methodologies to make evaluations on social, environmental, and corporate governance aspects. Normally, evaluations are made by using complex questionnaires and an analysis of public information sources. The criteria used by sustainability rating agencies are later reflected by the most prestigious sustainability indices.

Table 4: Results of questions on sustainability rating agencies and sustainability indices.

15. Have you heard of stock indices for socially responsible investment?

	YES	NO	No answer
N=345	26.1%	73%	0.9%
N=20	55%	45%	0%

16. Do you recognise any of the SRI stock indices in the financial market?

	N=345	N=20		N=345	N=20
Ethibel Sustainability Index	1.4%	10%	ASPI (ARESE Sustainable Performance Indices)	0.6%	0%
Dow Jones Sustainability Index	16.2%	40%	FTSE KLD 400 Social Index	1.7%	5%
FTSE4Good	7.5%	20%	Calvert Social Index	0%	0%
FTSE4Good Ibex	7.8%	20%	Other	1.4%	0%

17. Have you heard of sustainability analysis agencies?

	YES	NO	No answer
N=345	17.7%	79.1%	3.2%
N=20	30%	65%	5%

18. What is the most important or positive test for you when deciding to responsibly invest?

	N=345	N=20		N=345	N=20
EIRIS	2.9%	5%	SAM	1.4%	5%
Oekom research AG	0.9%	5%	ASSET4	1.4%	5%
Vigeo	1.2%	5%	KLD Research & Analytics Inc	0.9%	0%
Accountability	3.5%	10%	Other	3.2%	5%

19. What do you think will be the tendency in Spain regarding socially responsible investment?

	Decrease	No change	Increase	No answer
N=345	2.6%	18%	58%	21.4%
N=20	0%	15%	75%	10%

Sustainability indices and ESG (environmental, social, and governance) agencies are important sources of information for the socially responsible investor. However, these agencies remain little known by Spanish investors.

Only 26.1% of the sample has heard of sustainability indices. The best known index is the Dow Jones Sustainability Index (recognised by 16.2% of the sample and 40% of SR investors), followed by FTSE4Good Ibex (7.8%), FTSE4Good (7.5%), FTSE4 KLD 400 Social Index (1.7%), Ethibel Sustainability Index (1.4%), others (1.4%), and ASPI (0.6%). None had heard of the Calvert Social Index (Table 4).

The percentage of respondents who understand something about the role of sustainability rating agencies is 17.7%. The best known sustainability rating agencies are: Accountability (3.5% of the sample); other agencies (3.2%); EIRIS (2.9%); SAM (1.4%); ASSET4 (1.4%); Vigeo (1.2%); Research Oekom AG (0.9%); and KLD Research & Analytics (0.9%). The lack of familiarity with these agencies may be because agencies reveal little when explaining the

evaluation criteria used, particularly those related to risk management. As a result, a direct analysis of information by investors is difficult (Escrig et al., 2010).

Some 58% of respondents believe SRI will grow in popularity in Spain.

Factor analysis

Factor analysis is a multivariate statistical technique whose main aim is to synthesise the observed relationships among a set of variables in a concise and reliable manner as an aid to building new concepts and theories. Several studies in the literature have used this technique to analyse relationships of dependence and independence between variables of CSR (corporate social responsibility) or SRI (Anand and Cowton, 1993; Bigne et al., 2005). In our study we have examined these relationships with the following questions:

(4) Why have you chosen, or would choose, a financial product that incorporates social and environmental variables?
(5) Why have you not chosen, or would not choose, a financial products that incorporates social and environmental variables?
(10) What is the most important or positive criteria when deciding to invest in SRI?
(11) What is the most exclusionary or negative criteria when deciding to invest in SRI?

The results from the correlation matrix show that the only variable that can be eliminated in all cases (having a low factor loading) is the variable 'others' – it being the only variable with redundant information.

The logistic regression model

To analyse the influence of gender, educational level, and occupation in the various cases we used a linear probability model, namely, the logistic regression model (Alderete, 2006). This is a generalisation of the classic linear regression model for categorical dependent variables (Ato and Lopez, 1996). The main features include: (1) assumptions of normality and equality by variance-covariance matrices do not have to be met; (2) the model is more robust than other techniques when these assumptions are not met; (3) the use of continuous and categorical independent variables is enabled; (4) direct statistical tests are included; (5) nonlinear effects can be incorporated and the model is useful for diagnosis (Hair et al., 1999); and (6) the model is widely used in observational, survey, and experimental studies. Various studies have opted to use this model to analyse socially responsible relations and attitudes (Balaguer et al., 2008; Tranter and White, 2001; Chan and Wickramasinghe, 2006).

In our study, we have used three types of logistic regressions based on the type of dependent variable analysed. These regressions are: multivariate binary logistic regression when the dependent variable has two categories; multinomial logistic regression when the dependent variable has more than two categories; and ordinal logistic regression when the order of dependent variable categories is fixed.

Hypotheses

Below we identify the attitude and factors that motivate Spanish investors, and study the influence of gender (male-female), education level (university-no university), and occupation (employed-unemployed and non-actives).
Table 5 shows the hypotheses. The outcomes of the first analysis of the logistic regression test can be seen in the results column.

Table 5: Hypotheses for investors.

Dependent variable	Independent variable	Hypothesis	Test	Nature of the relation
Awareness_SRI	General level, education, occupation	H_1: Awareness_ SRI depends on the general variables, education, and occupation.	Multivariate binary logistic regression	H_1 depends on gender, education and occupation
Purchase_ SRI	General level, education, occupation	H_2: Purchase_ SRI depends on the general variables, education, and occupation.	Multivariate binary logistic regression	None
Awareness_ethical banking	General level, education, occupation	H_3: Awareness_ethical banking depends on the general variables, education and occupation.	Multivariate binary logistic regression	H_3 depends on education and occupation
Information_ SRIfunds	General level, education, occupation	H_4: Information_SRIfunds depends on the general variables, education, and occupation.	Multivariate binary logistic regression	H_4 depends on education
Evaluation_ SRIfunds	General level, education, occupation	H_5: Evaluation_ SRIfunds depends on the general variables, education, and occupation.	Multinomial logistic regression	H_5 depends on gender and occupation
Criteria _ positives	General level, education, occupation	H_6: Criteria_positives depends on the general variables, education, and occupation.	Multinomial logistic regression	H_6 depends basically on occupation
Criteria _ negatives	General level, education, occupation	H_7: Criteria_negatives variable depends on the general variables, education and occupation.	Multinomial logistic regression	H_6 depends basically on education and occupation
SRIfunds _risk	General level, education, occupation	H_8: SRIfunds_risk variable depends on the general variables, education and occupation.	Ordinal logistic regression	None
SRIfunds _returns	General level, education, occupation	H_9: SRIfunds_return variable depends on the general variables, education, and occupation.	Ordinal logistic regression	None
Awareness_indices	General level, education, occupation	H_{10}: Awareness_índices variable depends on the general variables, education, and occupation.	Multivariate binary logistic regression	H_{10} depends on education

Awareness_agencies	General level, education, occupation	H_{11}: Awareness_agencies variable depends on the general variables, education, and occupation.	Multivariate binary logistic regression	H_{11} depends on education
Tendency_ SRI	General level, education, occupation	H_{12}: Tendency_ SRI variable depends on the general variables, education and occupation.	Ordinal logistic regression	H_{12} depends on education and gender

Results of the model

After confirming the hypotheses H_1, H_2, H_3, H_4, H_{10}, and H_{11} which are related to the level of awareness and information, it appears that the gender variable does not influence in SR investment decisions except in H_1. The level of education variable is statistically significant, with some degree of relaxation ($p<0.10$) in H_1, H_3, H_4, H_{10} and H_{11}; while with some degree of relaxation ($p<0.10$) the occupation variable is significant in H_1 and H_3 (Table 6). We can therefore say that the degree of SRI awareness depends mainly on the education variable – as higher education generates a more informed society.

Statistical significance ($p<0.05$) would be an overly restrictive term, but a certain degree of relationship does exist (for example, $p<0.10$). The looseness of these recommendations is because a standard that is as restrictive as $p<0.05$ may lead to a failure to include in the model covariates with a weak association with the dependent variable in isolation. However, these covariates may prove strong predictors for the dependent variable when read in conjunction with other covariates. Research using statistical significance ($p<0.10$) is not uncommon in the literature such as Kale et al., 2002 and Co and Chew, 1997.

If we use for $p<0.05$ for the analysis then only the education variable is be significant in H_1. This may be due to the inclusion of interactions that involve excessive stratification for the available sample.

Table 6: Hypothesis tested through binary logistic regression.

			B	S.E.	Wald	gl	Sig.	Exp(B)
H_1	Step 1[a]	Gender(1)	-,477	,224	4,534	1	,033	,621
		Education_level(1)	-,853	,279	9,368	1	,002	,426
		Occupation (1)	,610	,256	5,659	1	,017	1,841
		Constant	,404	,168	5,788	1	,016	1,497
			B	S.E.	Wald	gl	Sig.	Exp(B)
H_3	Step 1[a]	Gender(1)	-,199	,239	,690	1	,406	,820
		Education_level(1)	-,788	,330	5,683	1	,017	,455
		Occupation (1)	-,457	,278	2,705	1	,100	,633
		Constant	-,414	,172	5,772	1	,016	,661
			B	S.E.	Wald	gl	Sig.	Exp(B)
H_4	Step 1[a]	Gender(1)	,096	,327	,087	1	,768	1,101
		Education_level(1)	-,778	,474	2,690	1	,101	,460
		Occupation (1)	,194	,359	,291	1	,590	1,214
		Constant	-1,885	,246	58,780	1	,000	,152
			B	S.E.	Wald	gl	Sig.	Exp(B)
H_{10}	Step 1[a]	Gender(1)	-,186	,251	,550	1	,458	,830
		Education_level(1)	-,856	,352	5,903	1	,015	,425
		Occupation (1)	,136	,279	,237	1	,627	1,145
		Constant	-,834	,182	20,957	1	,000	,434
			B	S.E.	Wald	gl	Sig.	Exp(B)
H_{11}	Step 1[a]	Gender(1)	,026	,288	,008	1	,927	1,027
		Education_level(1)	-1,030	,437	5,556	1	,018	,357
		Occupation (1)	,211	,317	,444	1	,505	1,235
		Constant	-1,433	,213	45,438	1	,000	,239

Hypotheses H_5, H_6, and H_7 are related to the evaluation of SRI funds and the positive and negative criteria for making an investment in this type of fund. For these hypotheses, we obtained the following results:

H_5: Gender is key variable when deciding to invest in SRI funds for the social aspects, and gender and occupation are crucial when considering environmental aspects (Table 7).

Table 7: Test for H_5: Evaluation_SRI.

H_5: Evaluation_SRI		B	Standard error	Wald	gl	Sig.	Exp(B)
Social aspects	Intersection	-,813	,201	16,366	1	,000	
	[Gender=0]	-,545	,279	3,816	1	,051	,580
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	,354	,323	1,201	1	,273	1,424
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	,292	,305	,914	1	,339	1,338
	[Occupation =1]	0[b]	.	.	0	.	.
Environmental aspects	Intersection	-2,236	,352	40,372	1	,000	
	[Gender=0]	-1,004	,495	4,107	1	,043	,367
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	,392	,520	,570	1	,450	1,480
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	1,038	,479	4,691	1	,030	2,823
	[Occupation =1]	0[b]	.	.	0	.	.

H_6: The occupation variable is statistically significant – with some degree of relaxation ($p < 0.10$) if the criterion for information transparency and help for training (Table 8).

Table 8: Test for H_6: Positive_criteria.

H_6: Positive_criteria		B	Standard error	Wald	gl	Sig.	Exp(B)
Information transparency	Intersection	,592	,305	3,771	1	,052	
	[Gender=0]	,055	,427	,017	1	,897	1,057
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-,256	,531	,232	1	,630	,774
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	,981	,528	3,451	1	,063	2,667
	[Occupation =1]	0[b]	.	.	0	.	.
Training help	Intersection	-1,471	,533	7,608	1	,006	
	[Gender=0]	-,209	,697	,090	1	,764	,811
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	,252	,782	,104	1	,748	1,286
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	1,466	,761	3,709	1	,054	4,332
	[Occupation =1]	0[b]	.	.	0	.	.

H_7: The gender variable is statistically significant – with some degree of relaxation ($p<010$), for criteria regarding activities that abuse the environment. The level of education variable is statistically significant with some degree of relaxation ($p<0.10$) for criteria regarding activities that abuse human and labour rights, lack of transparency and support for repressive and dictatorial regimes. Finally, the occupation variable is statistically significant, with some degree of relaxation ($p<0.10$), for activities such as nuclear production and animal testing, (Table 9).

Table 9: Test for H_7: Negative_criteria.

H_7: Negative_criteria		B	Standard error.	Wald	gl	Sig.	Exp(B)
Activities that abuse and human and labour rights	Intersection	1,811	,358	25,577	1	,000	
	[Gender=0]	-,037	,464	,006	1	,937	,964
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-,970	,522	3,454	1	,063	,379
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	,679	,580	1,367	1	,242	1,971
	[Occupation =1]	0[b]	.	.	0	.	.
Lack of transparency in business practices	Intersection	,903	,398	5,139	1	,023	
	[Gender=0]	-,435	,535	,660	1	,417	,648
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-1,616	,682	5,620	1	,018	,199
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	,985	,649	2,305	1	,129	2,678
	[Occupation =1]	0[b]	.	.	0	.	.
Nuclear production	Intersection	-1,188	,679	3,061	1	,080	
	[Gender=0]	-,120	,839	,021	1	,886	,887
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-1,895	1,204	2,478	1	,115	,150
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	1,793	,914	3,853	1	,050	6,009
	[Occupation =1]	0[b]	.	.	0	.	.
Activities that abuse the environment	Intersection	-,132	,496	,071	1	,790	
	[Gender=0]	-2,498	,877	8,116	1	,004	,082
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-,442	,720	,376	1	,539	,643
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	2,074	,736	7,930	1	,005	7,955
	[Occupation =1]	0[b]	.	.	0	.	.
Animal testing	Intersection	-2,145	,918	5,457	1	,019	
	[Gender=0]	,083	1,031	,006	1	,936	1,086
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-,398	1,089	,133	1	,715	,672
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	1,809	1,115	2,635	1	,105	6,107
	[Occupation =1]	0[b]	.	.	0	.	.
Support for repressive or dictatorial regimes	Intersection	1,080	,388	7,760	1	,005	
	[Gender=0]	-,683	,526	1,682	1	,195	,505
	[Gender=1]	0[b]	.	.	0	.	.
	[Education_level =0]	-1,170	,619	3,568	1	,059	,310
	[Education_level =1]	0[b]	.	.	0	.	.
	[Occupation =0]	,946	,636	2,214	1	,137	2,576
	[Occupation =1]	0[b]	.	.	0	.	.

Hypotheses H_8, H_9, H_{12} relate to risk, performance, and SRI trends in Spain. It can be seen that the gender, educational level, and occupation variables are not statistically significant for H_8 and H_9. Meanwhile, the gender and educational level variables for H_{12} are statistically significant – with a certain degree of relaxation ($p<0.10$) (Table 10).

Table 10: Test for H_{11}: Tendency_ SRI.

		Estimate	Standard error	Wald	gl	Sig.
Tthreshold	[Tendency_ SRI = 1]	-3,286	,352	87,052	1	,000
	[Tendency_ SRI = 2]	-1,004	,171	34,430	1	,000
	[Tendency_ SRI = 3]	1,720	,192	80,330	1	,000
Position	[Gender=0]	,510	,216	5,597	1	,018
	[Gender=1]	0[a]	.	.	0	.
	[Education_level =0]	,523	,262	3,984	1	,046
	[Education_level =1]	0[a]	.	.	0	.
	[Occupation =0]	,120	,237	,255	1	,613
	[Occupation =1]	0[a]	.	.	0	.

CONCLUSION

In this paper, we set out to study the perceptions held by the Spanish public regarding SRI criteria and real-life investment needs. We have conducted a field survey among 525 Spaniards.

The percentage of socially responsible individual investors in Spain is marginal (5.8% of the total sample). Most of these investors are women, in late middle age, highly educated, with middle and higher incomes – and students. The occupational and educational variables are the most important determinants when making investment decisions.

A certain lack of awareness was observed regarding SR financial products. The sustainability rating agencies and sustainability indices are the SRI market instruments least known by the Spanish respondents. On the other hand, ethical banks are the most known SRI market instruments.

As a result of our research we propose some aspects that could be improved in order to correct the main weakness to the growth of SR financial products in Spain are: (1) failure to publicise the existence of these products; (2) a perception of low returns; (3) a lack of adaptation of these products to the needs of investors; and (4) the limited development of SRI in Spain.

To tackle these problems, SRI Managers must create products and generate an economic return that reflect the social and environmental values of investors. In addition, retail investors must be informed in detail about the characteristics of these products. There is also the need for a greater promotion of SRI by the government.

Nevertheless, despite these drawbacks, there is an existing basis for growth (58% of the sample believes that SR investments will grow in the future).
Future work will seek to extend the study of the perception of SRI from Spain to a European level in order to evaluate the degree of integration enjoyed by these products and instruments in various European societies.

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THE IMPACT OF CHINA OIL DEMAND ON OIL PRICE AND RUSSIA TRADING SYSTEM INDEX

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ABSTRACT

China has become the second largest nation of consuming oil since 2002 and a net oil imported country from 1996. At the same time, global crude oil price and Russia Trading System Index (RTSI) also substantially went up to 2290.51 on June 2008 from 87.35 of 1996. Theses economic phenomena raise two issues discussed in this paper: Does the China oil demand carry the rising of the oil price? The second issue is how much the impact of China oil demand on RTSI? Estimates of Structure Vector Auto Regression models, employed for testing the impact of China oil imported on oil price and RTSI, bring up two conclusions: first, the continuing oil imported of China have a positive impact on oil price; second, the China oil imported also has a positive impact on RTSI. Therefore, the China oil demanded not only affects RTSI and Russia economic during Putin's Presidency but also the world crude oil price. These results indicate that China oil demand has a strong explanatory power to global oil price and RTSI fluctuation.

Keywords: Structure Vector Auto Regression; Russia Trading System Index; Johansen Co-Integration Test.

INTRODUCTION

Driven by economic continuing growth, China has become the second largest nation of consuming oil since 2002. Oil consumption raised from 173.8 million tones of 1996 to 368 million tones of 2007. But oil production only increased 28.2 million tones at the same time (BP Statistical Review of World Energy, 2008). Therefore, China becomes a net oil imported country from 1996. Crude oil imported, a remarkable growth from 36.61million tones of 1999, was up to 163.12 million tones in 2007. Meanwhile, the crude oil price rose to 2.74 times from 1999 to 2007. And Russia Trading System Index (RTSI) also went up from 59.7 of 1999 to 2290.51 of 2007. Figure 1 illustrates that global oil consumption grew at an average annual rate of 1.73% from 1996 to 2007. The increasing of oil demand results in the rising of

oil price. However, an average annual rate of China oil Consumption contribution to global growth of oil consumption is 29.06%.[1] The contribution rate reaches to 59.80% in 2006. On the other hand, the market value of energy industry is the most important component of RTSI. The top 3 of RTSI trading volume in 2007 were Gasprom ordinary shares with a turnover of 102.1 billion dollars, followed by LUKoil with a turnover of 46.4 billion dollars and RAO UES of Russia with a turnover of 41 billion dollars. The percentage of these securities in the turnover was 26.19%, 11.9% and 10.51% respectively (RTSa, 2008). Therefore, it is assumed that the increasing of oil demand results in the rising of oil price and the rising oil price will have an impact on RTSI.

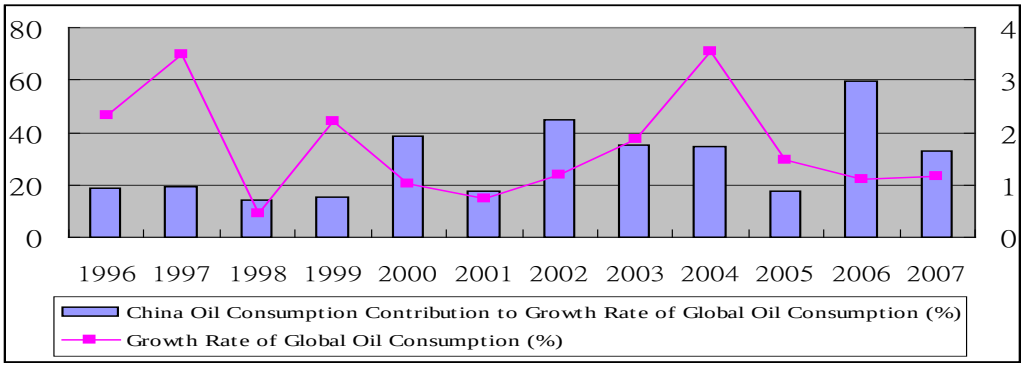

Figure 1: China oil consumption contribution to global growth of oil consumption and growth rate of global oil consumption, 1996– 2007.

Source: The data is from BP's Statistical Review of World Energy 2008.

Note: The number in the right side is the china oil consumption contribution to growth rate of global oil consumption and in the left side is the growth rate of global oil consumption.

Theses economic phenomena, with ascending trend from 1999, raise two issues discussed in this paper. Does the China oil demand carry the rising of the oil price? The second issue is how much the impact of China oil demand on RTSI?

The basic data used for investigating these two hypotheses are presented in figure 2-4. Estimates of Structure Vector Auto Regression (SVAR) models, employed for testing the impact of China oil imported on oil price and RTSI, suggest two conclusions: the quantity of China oil imported has a positive impact on oil price between the first and the third period and the result is statistically significant; second, the quantity of China oil imported also has a

[1] An average annual rate of China Oil Consumption Contribution (China_coms) to Global Growth of Oil Consumption (Global_coms) is calculated by following formula: [China_coms(t)-China_coms(t-1)] / [Global_coms(t)-Global_coms(t-1)]. And an average annual rate of China and India oil consumption contribution to global growth of oil consumption is 38.33%. In other words, the increment amount of India oil consumption contribution to the increment amount of global growth of oil consumption only 9.27%. Therefore, we think that the increment amount of China oil consumption is a main reason of the rising of global oil consumption.

positive impact on RTSI between the first and third period, and is statistically significant. The demand of China oil imported has a positive impact on crude oil price. The rising of crude oil price leads to increase the quantity of Russia oil output. At the same time, the oil industry is the most important industry relative to Russia Macroeconomic environment.[2] Therefore, the demand of China oil not only affects the world crude oil price but also RTSI and Russia economic during Putin's Presidency. It implied that the oil demand of China affords benefit to Russia[3].

THE QUANTITY OF CHINA OIL IMPORTED, OIL PRICE AND RTSI ON 1996-2008

Figures 2-4 present the quantity of China oil imported; Price of West Texas Intermediate Crude and RTSI; Price of West Texas Intermediate Crude estimated in constant dollars. Monthly quantity of China oil imported, Price of West Texas Intermediate Crude and RTSI from 1996-Jan to 2008-June are unadjusted. The quantity of China oil imported and the Price of West Texas Intermediate Crude have a statistically significant correlation coefficient that is 0.8730. The three series indicate statistically significant upward trends.

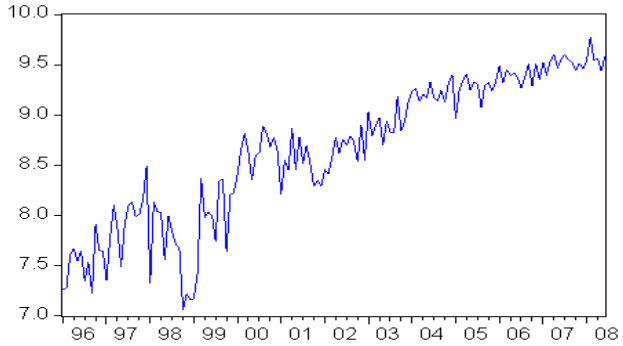

Figure 2: The Quantity of China Oil Imported, 1996-Jan – 2008-June

Source: The data is from IMF's international financial statistics.

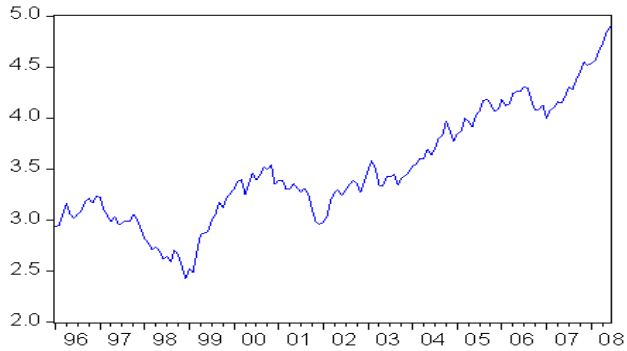

Figure 3: Price of West Texas Intermediate Crude, 1996-Jan – 2008-June

[2] Russia Fuel-Energy Complex provides about 1/4 GDP, 1/3 value of industry output, 1/3 federal budget revenues, 1/2 export revenue and 1/2 foreign reserve (The Ministry of Industry and Energy of the Russia Federation, 2003).

[3] Padma Desai (2006) also thinks that the Russian economy began the new millennium with robust real GDP growth averaging close 6 percent from 1999 to 2004 by expanding oil production.

Source: Economic Time Series Page.

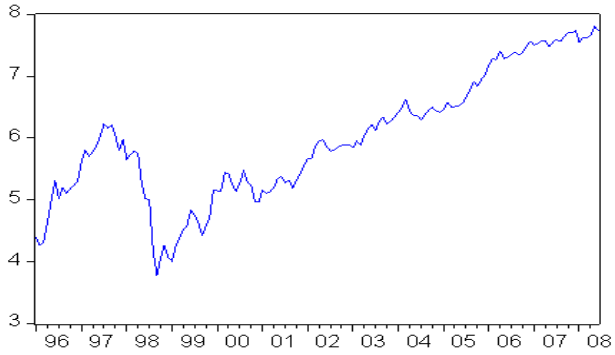

Figure 4: Russia Trading System Index, 1996-Jan – 2008-June

Source: Russia Trading System (RTSb).

The Models

Blanchard and Quah (1989) proposed the approach of long-run SVAR to examine the sources of the macroeconomic fluctuations. The advantage of the long-run SVAR model is that the model doest not impose contemporaneous restrictions, but it allows the data to determine short-run dynamics based conditionally on particular long-run restrictions. This approach is popular to employ in examining the sources of macroeconomic fluctuations. For example, Lastrapes (1992) extended this approach in examining resources of real exchange rate fluctuations. Chen and Wu (1997) also applied the long-run SVAR model to analyze the influence of real shocks on the fluctuations of real exchange rates for four Pacific Basin countries. The long-run SVAR model used to analyze the impact of the quantity of China oil imported on oil price and RTSI is stated here. The variables are defined as the quantity of China oil imported (O_q), oil price (O_p) and RTSI (rts). All variables are in logarithms.

The conventional VAR model is:

$$Y_t = B_0 + B_1 y_{t-1} + \ldots + B_p Y_{t-p} + U_t \quad \text{--- (1)}$$

Where $Y = [\Delta O_q \;\; \Delta O_p \;\; \Delta rts]'$, $B_i's$ are matrices of unknown structural coefficients.

Y_t can consist of the unobservable disturbances and be represented by:

$$Y_t = A(L)U_t, \quad \mathrm{Var}(\mathrm{U}_t) = I \qquad (2)$$

Y_t has a unique Wold-moving average representation:

$$Y_t = C(L)V_t, \quad \mathrm{Var}(\mathrm{V}_t) = \Omega, \quad \mathrm{C}_0 = I \quad (3)$$

To obtain $C_i's$, we can invert the estimated coefficients, after estimation the vector autoregressive representation of Y_t. Comparing equation (2) and (3), one can obtain:

$V_t = A_0 U_t,\ \text{and A}_\text{i} = C_i A_0,\ \text{i} = 1,2,...,\text{p}$

A_i can be solved when A_0 is known, since C_i is obtained by inverting VAR's estimated coefficients. In this paper, A_0 is 3*3 matrix; therefore, the unique determination of the nine elements of A_0 require three independent restrictions.[4] Therefore, we need three restrictions to solve the A_0. In this paper, we assume that oil price shocks and RTSI shocks have no long-run effect on the China import Oil demand and RTSI shocks have no effect on oil price in the long run.[5] Using there restrictions, along with those restrictions provided by the variance covariance matrix, can be determined the A_0 matrix and therefore get all A_i matrices. Finally, on can figure out the process of Y_t form equation (2) under having the matrices of U_t and $A_i's$. Our purpose is to use the impulse response functions and variance decompositions to capture the important dynamic characters of the empirical model and the sources of fluctuations.

Analysis of Empirical Results

Unit Root Test and Johansen Co-Integration Test

Before proceeding with our estimation, we need to determine the stationary of data. We employ the conventional Augmented Dickey-Fuller (ADF) unit root test to examine the integration properties of the quantity of China oil imported, oil price and RTSI. The lag of unit root test was determined by minimal Akaike Information Criterion (AIC). Both statistics of $\tau_\mu$and τ_τ show that all variables are non-stationary (i.e. I (1) process) except that O_q variable in τ_τ statistics is stationary in 5% (see table 1). However, it fails to reject the null in 1%. To avoid the possibility of spurious estimation from the structure VAR model, we will question the co-integration among the quantity of China oil imported (O_q), oil price (O_p) and RTSI (rts) given the fact that we fail to reject the I(1) null for data. We therefore apply the multivariate co-integration techniques provided by Johansen (1991) to examine the existence of a long-run relationship between the previous three variables. The lag order of the level VAR is selected by minimal AIC and it suggested that the optimal lag order is 3.

Table 2 illustrates the results of the co-integration test which were derived using the

[4] The variance covariance matrix $A_0' A_0' = \Omega$ provides six restrictions.

[5] According the report of National Center for Policy Analysis, the world's oil supply will not be exhausted until the year 2056 (David, 2003). In addition, China's oil demand has not reduced because of the oil price greatly rises from past history, and the oil demand of China is mainly influenced from Chinese economic growth, not from RTS. Therefore, we assume oil price and RTS have no effect on China's oil demand in the long-run. At the same time, the factors of affecting oil price may be due to the oil demand of China or depreciating dollars, not RTS.

Johansen method. Both the maximum eigenvalue $(\max\lambda)$ and the trace statistics demonstrate the existence of non co-integration among variables. The finding of no co-integration implies that there is no linear long-run equilibrium relationship among variables. Therefore, the VAR model can be applied to examine the sources of RTSI fluctuations.

Table 1: ADF Unit Root Test.

Level	τ_μ	τ_τ
O_q	-1.200 (3)	-3.596* (3)
O_p	0.801 (0)	-1.401 (0)
rts	-1.109 (1)	-2.418 (4)
Diff		
O_q	-10.520*(2)	-10.487* (2)
O_p	-10.821*(0)	-10.960* (0)
rts	-10.382*(0)	-10.344*(0)

Note: The lag order of ADF model is in brackets which obtains by min AIC.

Table 2: Johansen Co-integration Test.

Model: China oil import, Oil price, RTSI				
Model 3	Trace	5%C.V.	Max λ	5%C.V.
$H_0:\gamma=0$	22.794	29.797	13.411	21.132
$H_0:\gamma\le 1$	9.383	15.495	9.337	14.265
$H_0:\gamma\le 2$	0.046	3.841	0.046	3.841
Model 4	Trace	5% C.V.	Max λ	5%C.V.
$H_0:\gamma=0$	38.273	42.915	18.256	25.823
$H_0:\gamma\le 1$	20.017	25.872	13.378	19.387
$H_0:\gamma\le 2$	6.639	12.518	6.639	12.518

Notes:

1. Maxλ denotes the maximum-eigenvalue statistics

2. The critical values of the trace and the maximum-eigenvalue statistics are obtained from Johansen and Juselius (1990).

Variance Decompositions

The variance decompositions analyze the relative contribution of forecast error variance of each shock as a function of forecast horizon. It is a convenient measure of the relative importance of shocks to the system. Table 3 are reported by the variance decompositions of the quantity of China oil imported of SVAR for second, eighth, and fourteenth forecast

periods. For example, the fraction of the forecast error variance in the quantity of China oil imported attributable to a RTSI shock is 11.24 percent in the second forecast period. RTSI structural errors can explain 13.67 percent of the forecast error variance of the quantity of China oil imported in the eighth forecast period at their maximum. At the same time, the fraction of the forecast error variance in the quantity of China oil imported attributable to the oil price shock is 12.27 percent in the second forecast period, and these estimates are statistically significant.

Table 3: Variance Decomposition of the quantity of China oil imported.

	2	8	14
ΔO_q	76.49	74.42	74.42
ΔO_p	12.27	11.91	11.91
Δ rts	11.24	13.67	13.67

Notes: Each row gives the percentage of the forecast error variance of the quantity of China oil imported in a given month with respect to the structural error of the row variable.

Source: The estimates are derived from SVAR model.

Table 4:Variance Decomposition of the crude oil price.

	2	8	14
ΔO_q	13.76	13.68	13.68
ΔO_p	85.59	84.88	84.88
Δ rts	0.65	1.44	1.44

Notes: Each row gives the percentage of the forecast error variance of the crude oil price in a given month with respect to the structural error of the row variable.

Source: The estimates are derived from SVAR model.

Table 5:Variance Decomposition of the RTSI.

	2	8	14
ΔO_q	20.34	20.18	20.18
ΔO_p	1.46	2.30	2.30
Δ rts	78.20	77.52	77.52

Notes: Each row gives the percentage of the forecast error variance of the RTSI in a given month with respect to the structural error of the row variable.

Source: The estimates are derived from SVAR model.

The variance decompositions of crude oil price derived from SVAR model in table 4 are also robustly estimated. At their maximum, the fraction of the forecast error variance in the crude oil price attributable to the quantity of China oil imported shock is 13.76 percent in

the second forecast period. The structural errors of the quantity of China oil imported can explain the fractions of the forecast error variance of crude oil price. On the other hand, the fraction of the forecast error variance in the crude oil price attributable to a RTSI shock ranges from 0.65 percent in the second month to 1.44 percent in the fourth and eighth month of the forecast horizon, and these estimates are statistically insignificant.

Table 5 are listed the variance decompositions of RTSI. The quantity of China oil imported structural error contributes 20.34 percent of the forecast error variance of RTSI in the second forecast period. These estimates almost stay at 20.18 percent from the eighth to fourteenth forecast period. These estimates are statistically significant. By contrast, the fraction of the forecast error variance in RTSI attributable to crude oil price shock ranges from 1.46 percent in the second month to 2.3 percent in the eighth and fourteenth month of the forecast horizon, and these estimates are statistically insignificant. It may be that the quantity of China oil imported has a very strong relationship to crude oil price.[6] Therefore, the impact of crude oil price on RTSI had been explained on regression.

Impulse Response Functions

The impulse response functions reveal the dynamic effects of a positive one-standard-deviation shock to a variable on other variables. Figure 5 illustrates the responses of China oil imported, oil price and RTSI with respect to structural shocks came form China oil imported, oil price and RTSI, respectively. The magnitude of the shocks and the resulting impulse responses for 10 months of the forecast horizon are measured in terms of one standard deviation. It is interesting that the response of the quantity of China oil imported with respect to a one-standard-deviation structural shock to the oil price, the responses of the level of oil price to the quantity of China oil imported disturbance, and the responses of the level of RTSI to the quantity of China oil imported disturbance in Figure 5.

The quantity of China oil imported is affected negatively in the first forecast month by a positively shock in the crude oil price. The relationship between the quantity of China oil imported and the crude oil price in the first forecast month is negative because of the rule of demand. However, the second response of the quantity of China oil imported to the crude oil price is positive which corresponds to a strong oil demand of China, and the result is statistically significant. This effect seems to be smaller from the third forecast period.

The response of crude oil price to a one-standard-deviation structural shock in the quantity

[6] The quantity of China oil imported and the Price of West Texas Intermediate Crude have a statistically significant correlation coefficient that is 0.8730.

of China oil imported from SVAR model. The initial response of crude oil price to a positive structural error in the quantity of China oil imported is positive because of a strong oil demand of China, and it is statistically significant. The response becomes zero after the third forecast period. On the other hand, the response of RTSI to the quantity of China oil imported is also positive and statistically significant in the first forecast month. This effect also becomes smaller from the third forecast month.

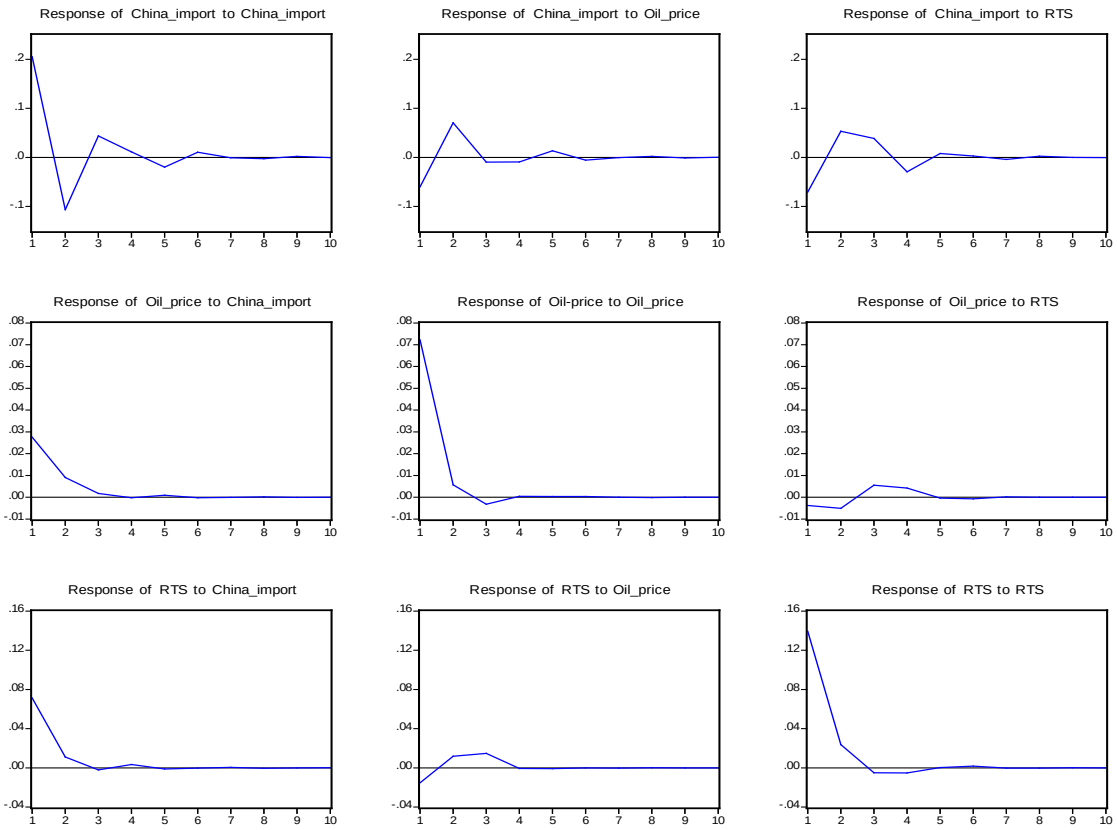

Figure 5: Impulse Response Function (Response to Structural One S.D. Innovations).

Source: The estimates are derived from SVAR model.

CONCLUSION

Two conclusions and economic phenomena implications emerge from these estimates and analysis. First, the evidence provided by the variance decomposition and the impulse response functions is conclusive with respect to the impact of the quantity of China oil imported on the global crude oil price. Second, the quantity of China oil imported also has an impact on RTSI and is statistically significant. However, the rising of the oil price is the main reason of Russia economic growth and political stability. Wu (2008) use the Granger Causality test and Impulse Respond Function to examine causality between crude oil price and per capital GDP and the impact of changing crude oil price on per capital GDP from 1992

to 2007. He found that the increase in crude oil price is shown to be a significant influence and positive impact on the growth rate of Russian per capital GDP. In other words, the global crude oil price was driven by the demand of China crude oil. And the rising of global crude oil price has a positive impact on Russian economic growth. Therefore, Russia economic growth seems to be driven by the demand of China crude oil. The results indicate that China oil demand has a strong explanatory power to global oil price and RTSI fluctuation from 1996-Jan to 2008-June.

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E4 – Trust in business relationships

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TRUST IN WORK RELATIONSHIPS: A SOLUTION FOR OVERCOMING CULTURAL HINDRANCES TO ORGANIZATIONAL INNOVATIONS?

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ABSTRACT

This paper discusses a timely issue of trust in work relationships as a basis for collaboration in intra- and inter-organizational interactions and a driver for innovativeness, accordingly. In organizations, renewing of human capital enhances innovativeness and creativity. In general, managers and leaders are those who are liable for knowledge sharing, motivation and learning culture needed for renewal of human capital. Trust is a main element of social capital and a basic dimension of leadership for innovative organization culture. Especially in the knowledge era, trust building is seen as a leader's essential task, especially in knowledge intensive organizations. Vitality and innovativeness in organizations are fostered through 'leadership by trust'. In the empirical study, the data includes stories collected by a method of empathy-based stories and analyzed by content analysis and analysis of narratives. The paper discusses actors' experiences and perceptions of trust in intra-organizational relationships and how trust is related to organizational culture to foster innovativeness. More specifically, the purpose of this paper is to discuss how muteness and the 'habit' of unopen communication in Finnish workplaces might be a block hindering trust building and restoring of it.

Keywords: Interpersonal trust, trust building, trust breaking, organizational innovativeness, method of empathy-based stories

INTRODUCTION

Trust as a multidisciplinary issue has been widely studied over the last few years in different fields of science (Ebert 2009). However, trust is a complex, multifaceted phenomenon, and different conceptualizations of the nature of trust exist in interpersonal relations, for example, trust between peers, supervisor-subordinate trust, managerial trust and organizational trust (Möllering et al. 2004). Trust is a main element of human capital and a basic dimension of innovative organization culture. In Finland, the significance of trust in leadership is visibly recognized and highlighted by the Development Program of Finnish Innovation Fund SITRA and *leadership by trust* is seen as a source of national vitality and a key element of innovativeness (Nurmio and Turkki 2010; Savolainen 2011). Within organizations, the role of trust is crucial when generating social capital and fostering job satisfaction, organizational behaviors and

commitment, turnover and job performance (e.g. Lewicki et al. 2006; Bijlsma, K. and Koopman, P. 2003).

In leadership, trust is seen as the essential element of intra- and inter-organizational social system, as a 'building block' and connecting 'device' of relationships. Trust enables more open interpersonal communication in groups and organizations thus contributing to information and knowledge sharing in network relationships (Savolainen 2010). Trust is often taken for granted at organizational level and in interactions until it is broken. Effects and consequences of trust are many such as promoting of adaptation to new organizational forms, for example, to network relations, and even crisis situation, flexible organizing of groups, reducing negative conflicts, and decreasing transaction costs. On the contrary, if a leader refuses guidance and support and criticizes the followers, trust collapses.

The purpose of this study-in-progress (aimed to be a doctoral dissertation) is to increase and deepen understanding of the development, maintenance and repair of dyadic trust within the Finnish organizational contexts. First, the research aims at describing how leaders and subordinates describe their experiences and perceptions of intra-organizational trust and distrust. Second, the study poses to questions how leaders and managers enact on building and sustaining trust in organizations and how leaders develop trust-building and -repairing skills to enable innovativeness in the organization. Hence, the issue is closely related to trustworthiness (Savolainen and Häkkinen 2011). Furthermore, the paper aims to discover whether the method of empathy-based stories (MEBS) can be applied to trust research.

THEORETICAL FRAMEWORK

Concept and nature of trust

Early trust researchers such as Deutsch (1962) depicts that trust comprises of a person's beliefs and expectations on how the trustee will behave. Rotter (1967), also one of the early trust theorists, has defined interpersonal trust as expectancy by an individual or a group that the word, promise, verbal or written statement of another individual or group can be relied upon. Recently, scholars have distinguished between relation-based trust which has an affective basis, and character-based trust which has a cognitive basis (Zucker 1986; Dirks and Ferrin 2002; Gillespie and Mann 2004). Relation-based affective trust refers to the role of emotions and the process of trust development; character-based trust refers to beliefs about another's trustworthiness (Gillespie and Mann 2004). In psychology trust is investigated in the levels of cognition, affection and behavior. According Jones and George (1998) the states of trust are conditional, unconditional and distrust and the experience of trust and the interplay of individual's values, attitudes, and moods and emotions is emphasized in the process. The key component of trust is willingness to be vulnerable. Mayer et al. (1995) have developed a model of organizational trust in which several characteristics of the both parties lead to trust, which is defined as:

> The willingness of a party to be vulnerable to the actions of another party based on the expectations that the other will perform a particular action important to the trustor,

> irrespective of the ability to monitor or control that other party. (Mayer et al. 1995, 712).

Trust is dynamic, volatile and contextual in nature (Lewicki et al. 2006, 992). The attributes of uncertainty, complexity and risk describes the concept. Trust involves a risk to become betrayed or wounded despite of the positive endeavours of trust in developing openness, and effective co-operation (Savolainen 2010). Uncertainty originates from the risk and expectations (Savolainen 2008, 3). Trust is about taking risk (McAllister 1995, 184) and involves willingness to take risk (Mayer et al. 1995). Thereby trust is exposed to blindness and deceptive action (Nooteboom 2003, 1; Ferrin et al.). Activities are based on knowledge, knowing and especially exploitation. Trust is 'fragile' and can be broken easily (Savolainen and Ikonen 2010, 2).

Trust is built in the course of time and of compatible words and actions (Mishra 1996, 268; Lewicki and Bunker 1996, 119). In addition trust is based on mutual, legal and psychological agreements. Trust development is a process and a psychological state (cf. Kramer 1999, 571) and functional state with different phases and levels. The process seems complex, non-linear, and non-straight forward with more of a wave like development (Laaksonen 2010; Savolainen, 2011; Ikonen and Savolainen 2010). McAllister (1995) have provided evidence for the fact that trust has cognitive and affective aspects (Lewis and Weigert, 1985). Trust can be founded on emotions and cognition of an actor. Cognition-based trust expresses rationalism and knowledge (McAllister 1996, 25-26).

Trust is a foundation for cooperation between organizational actors. Currently, virtuality and e-business extend fast emerging increasing challenges in building sustaining trusting relationships within and between organizations. They call for new approaches to organizational leadership such as e-leadership (Avolio et al. 2009). Successful relationships are seen to enable organizations to cope with levels of uncertainty in times of changes (Atkinson 2004). As to the development of trust, prior research has presented various perspectives on that except of the strategy process view which is not yet explored. Researchers have suggested models comprising stages (Lewicki and Bunker 1995; 1996) and interactive processes of trust development (McAllister, Lewicki and Chaturvedi, 2006, 1). According to Lewicki and Bunker (1996, 120) trust develops in three stages. They call the stages as follows: *calculus-based trust, knowledge-based trust and identification-based trust*.

The model is a linear type of progressive model and is criticized and questioned among others by Savolainen (2009; 2010; Ikonen and Savolainen 2010; see also Laaksonen 2010). She has elaborated a theoretical idea of integrating the LMX-theory of leadership 'making' by Graen and Uhl-Biem (1995) with Lewicki and Bunker trust model. Trust develops dynamically in relationships in three stages that also describe the changes in *the foundations of trust.* The development of trust proceeds from calculative-based to competence-based trust, and finally, to identification-based trust. The better the other party is known the deeper the relationship between the parties develops in the course of time. These two models can be linked with each other in the sense that they look at a developmental nature of relationships and are also

related to trust in relationships. Development is assumed to be progressive, i.e., relationships are seen to progress towards a deeper or more advanced level.

Both models are based on the same progressive assumption, which can be critiqued, as the process may not be linear in reality. It is the purpose of the study to explore the process. In the theoretical model, progressing towards a higher level of trust requires *reciprocal, continuous interaction.* This fits the trust definition adopted in the paper (Mayer et al. 1995). Integration of the leadership development model and trust-building model *synthesizes the two perspectives* for identifying three developmental stages of trust in leader-follower relationships: the alien-calculative, acquaintance-competence, and company-identification stages of. Therefore, the integration of the models forms in fact a way to study trust development *processually*, i.e., to understand and analyze the main dimensions, stages, features and factors related to the process and dynamics of how interpersonal trust develops between actors.

Leader-Member Theory

The theoretical framework of the study draws upon the Leader-Member Exchange (LMX) theory and the stage models of trust development (Graen and Uhl-Bien; Lewicki et al. 2006). The theoretical perspectives are integrated to form a way to study critically and understand the nature, main dimensions and factors of trust development. According LMX-theory which is used as a salient frame of this study, there is a unique relationship that the leader builds with each follower. Trust has a central role in this process. LMX-theory emphasizes the importance of interaction and communication but also reciprocal trust, respect and commitment. Trust building is essential in leadership and one of the leaders' tasks among others. That is why it is also feasible to talk about 'making leadership' and 'being a leader' in relation to Leader-Member exchange theory. The theory is applied in the study because the assumptions and interests are closely aligned with theories of interpersonal trust. The conceptions are relevant to use as a part of theoretical frame of current study, because leadership is seen as a process over time in LMX-theory (see also Scandura and Pellegrini 2008). Graen and Uhl-Bien (1995, 240) have stated building leadership into three phases of life cycle of leadership making: strangers, acquaintance and maturity. Mature partnership exchanges are not only behavioral but also emotional mutual - support, respect and trust empowers and motivates both (Graen and Uhl-Bien 1995).

LMX theory seems to be salient for this current study because of its useful concepts describing the development of leader-member relationship. In prior research, trust is examined within LMX framework (e.g. Brower et al. 2000). Generally, LMX theory is strongly developed by quantitative methods. In other words, the ontological and epistemological assumptions of most of studies concerning LMX theory so far are different from the methodology of our paper. However, the qualitative roots of studying leader-member exchange relationships do exist (Fairhurst 2007, 120); and theory can be build forward through different approaches by integrating results. A more constructionist approach in understanding LMX relationships provides an opportunity to gain in-depth understanding of the leader-follower relationship and

trust within it (see, e.g. Fairhurst 2007). The role of the framework is to form a pre-understanding on the topic in seeking answers to research questions.

METHODOLOGY

Qualitative approach

Trust research has a long quantitative tradition. In this study, a qualitative approach has been adopted, as the interpretive approach and qualitative methods have become more common in leadership research (Koskinen et al. 2005). This approach pursues descriptions of the phenomena studied and aims to gain understanding of the *perceptions* of actors, individuals and groups, in their own contexts. The starting point of interpretive research is the idea of an organization as a socially constructed reality. Therefore, this reality can be investigated from multiple and different points of view not excluding one another. The paper discusses the actors' perceptions of trust in intra-organizational relationships. In the empirical study, the data includes stories written by students, which are collected by a method of empathy-based stories and analyzed by content analysis and narrative methods (Eskola 1997b; Kovalainen and Eriksson 2008). We argue that the earlier results only provide an incomplete picture about the trust development in intra-organizational relationships.

Method of empathy-based stories

The method of empathy-based stories (MEBS) was developed in Finland in 1980s. The method is based upon the assumption that people can express their understanding of social situations and episodes in a form of a story rather than answering to researcher's questions (Eskola 1997a, 173). The advantages of MEBS are its ease of use, low price and quickness (Eskola 1977b, 32). Furthermore, it solves most of the ethical problems of trust research and the saturation of the data is reached rather easily. On the other hand, data never saturates, because in a sense a researcher can analyze the data from different perspectives over and over again. Nevertheless, MEBS provides both challenges and unusual possibilities of analysis. For example, the method facilitates the capture of cultural meanings of a particular situation, such as trust building or trust violating in the present study.

The empirical data of the study is collected by the method of empathy-based stories (MEBS) among students of the university. The empirical data includes stories written by students and these stories are analyzed by content analysis and narrative methods. MEBS provides both challenges and unusual possibilities of analysis.

Data collection

The stories were collected from 42 students of the course of Qualitative Methods in Business Research at the University of Eastern Finland, Joensuu Campus, in November 2010. In the beginning of the lecture, the students were guided by a few words of the theme of the study ("trust in leader-follower relationships") and they were allowed to use their imagination in empathizing in the situation of the frame story:

> Imagine, that you are working as a summer trainee accounting assistant at a local company. Marketing director Mr. Petri/ Ms. Petra Lumivuori behaved in a trust building/ breaking manner towards you. Describe what happened. [Translation M.I.]

Each student got one of the four variations of the frame story on a sheet of paper and was asked to continue the story for 10-15 minutes. The only background information required was the gender of the writer.
The study includes four (4) variations of the frame story:

A. Trust building by a male leader (11 stories)
B. Trust breaking by a male leader (12 stories)
C. Trust building by a female leader (10 stories)
D. Trust breaking by a female leader. (8 stories)

Narrative and content analyses

Narratives, or stories, are typical ways to clarify reality, and narration is close to normal speech (Kovalainen and Eriksson 2008). In fact, the human world is based on story-telling and listening and the stories and tales have become interests of research. Narrative research is interested in how people themselves interpret events and then, researcher interprets these interpretations. All in all, narrative research covers a multitude of possibilities to carry out research.

As a preliminary analysis, we have developed *metastories* from these individual stories focusing on trust building and trust breaking by selecting items that might be significant and relevant to the logic of the story (Eskola 1997a, 174). Then, these metastories have been analysed by content analysis. Content analysis (regarded as a qualitative analytical methodology) is often the first qualitative technique for analyzing qualitative data when other methods are also utilized. In the analysis of the stories we have concentrated on what changes in the stories in the variations. The method enables to capture cultural meanings of a particular situation such as trust building or trust violating in this case.

The data is analyzed holistically in qualitative research. During the analysis, the attention is drawn to essential issues and details on the basis of the theoretical framework and the research questions. In our interpretation, we have aimed at finding something that not said out straightly. As usual in qualitative research, the interpretation is more or less speculative.

FINDINGS

Preliminary findings of the study support the prior results of the research group (Ikonen 2010a; Ikonen 2010b; Ikonen and Savolainen 2010a; Ikonen and Savolainen 2010b; Häkkinen et al. 2010; Häkkinen et al. 2011) indicating that integrity, listening to subordinate, appreciating his or her opinion, and keeping promises are the main elements of efficient functioning relationship in organizations. These findings by themselves are quite unsurprising indicating

that informal discussion with subordinates, appreciation of their work and opinions and honesty are the most important elements of trust building. Furthermore, standing with subordinates and giving both responsibility and help are crucial in trust development in leader-follower relationships. These findings have been reported in other studies (Brower et al. 2000; Bijlsma and van de Bunt 2003; Gillespie and Mann 2004). The consequences of trust building appear reciprocity, mutual appreciation, motivation and positive emotions such as safety and boldness which can create the atmosphere more encouraging and foster innovativeness.

Our most interesting results, however, are found when we investigate trust breaking behaviors within our data. Surprisingly, gender differences were not emphasized in the stories but a kind of muteness and the 'habit' of indirect and unopen communication in workplaces. A typical reaction of a subordinate in a case of trust eroding seems to be *avoiding* discussion with the leader but telling to workmates:

Story B2: I am disappointed with the behavior of the marketing manager. In future, I will discount her words. I shared my disappointment with my nearest colleagues. [Translation M.I.] (Male account assistant and male marketing director)

Therefore, we need to ask how this kind of muteness and indirect communication in Finnish workplaces are related to trust building in leadership as a source of national vitality for competitiveness, and how it influences innovativeness. Is it a block or hindrance? Does this kind of atmosphere resist and hinder even sincere attempts to building and restoring trust? Evidently, interpersonal trust formation is a reciprocal process between actors, anyway. According to our data, competency is highly appreciated as an antecedent of trust in Finnish workplaces. Competency, or ability, is one of the dimensions of trustworthiness (Bijlsma, K. and van de Bunt, G. 2003) which is emphasized within our results. For example, if a leader refuses guidance and support and criticizes the followers, trust collapses:

Story B1: Mr. Lumivuori insisted that I have miscounted the marketing budget. Still, it is obvious that he is the one who do not understand the numbers. He has estimated the costs substantially low and now I am just wondering how a person who do not understand numbers at all could be in the position he is in a company. The situation was handled by CEO who clarified the reasons of calculations to Mr. Lumivuori. Yet he argued that I had given unclear reasons to him. [Translation M.I.] (Male account assistant and male marketing director)

However, it seems that few male subordinates are more determined to straighten out their differences strictly with their leaders whereas a few of female subordinates are tempted to discuss about these problems with their workmates. In general, building trust among leaders and followers in organizations takes time; yet, trust is tested in relationships and can be broken in a moment. Misunderstanding and miscommunication are common in work relationships (e.g. McAllister 1997). However, repaired trust can become more confident than trust that has never been tried:

Story D3: I discussed privatively with her explaining my point of view and gave reasons why her behavior towards me was inappropriate. In the discussion, the highly charged situation was settled down constructively which brightened up our mutual trust. [Translation M.I.](Male account assistant and female marketing director)

The preliminary findings indicate that the intra-organizational actors' perceptions of trust differ by position, tenure and gender. Interestingly, the perceptions of distrust were described with strong emotions and discrimination between organizational actors. The national organizational culture is strongly reflected in students' stories. The leaders are mainly responsible for the change of the organizational culture. On the other hand, gender differences are not emphasized in the current study. As managerial implications, the study shows, for example, that repaired trust can become more confident than trust that has never been tried. Leaders should be encouraged not only to build trust in their relationships with subordinates but also learn to sustain it as Scandura & Pellegrini (2008, 107) suggest. In conclusion, the results of the study shows that the method of empathy-based stories can claim to provide a richer and deeper view on interpersonal trust in renewing human capital. Especially, the method of empathy-based stories (MEBS) demonstrated a promising alternative for data collection concerning a mundane and complex phenomenon.

CONCLUSIONS

The findings imply that the role and practices of trust needs to be considered more carefully and dynamics of intra- and inter-organizational relationships understood more deeply, as the relationships may be multiplex. Arising the level of awareness of the significance of trust and developing trust building skills in organizations may remove obstacles in pursuing trusting network relationships (Savolainen 2010). For further research the paper suggests that trust development needs to be studied empirically in real life contexts. Despite increasing amount of research work on social and inter-organizational networks, it is the dynamics and processes of interpersonal trust development in relationships that are still largely unknown.

Practical implication is that trust is crucial to develop and encourage in organizations; in development of leadership skills building trust and showing trustworthiness cannot be overestimated in the current business environments making strong requests of cooperative abilities in daily leadership practices (Ikonen and Savolainen 2011). Practices of trust show also how intra-organizational trust in work relationships affects *inter*-organizationally, customer interaction, in this case (Savolainen, 2010). Dynamics seem to work through organizational climate, functioning of interpersonal relationships which involve also trustful behaviour towards peers.

The results of the study indicate that trust is crucial in knowledge sharing and acceptance of diversity. Currently, diversity is one of the main culture-related issues in business life. It is also to do with innovativeness. The fruitful environment for innovations emerges from cooperation

of different professionals and specialist working, for example, with same issues and problems. The success of innovative networks is based on expertise and knowledge sharing and ability to combine several perspectives and approaches. Innovations are often created in the interfaces of knowledge and for that trust building is crucial (e.g. Kansallinen innovaatiostrategia 2008).

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THE CONCEPT OF TRUST IN ORGANIZATIONAL LIFE IN EXAMPLE OF POLISH ENTERPRISES[1]

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ABSTRACT

The concept of trust has become popular in public debate and academic analysis. In high income countries this interest is associated with concern for the decline of trust in governments and professionals, and in developing countries has been prompted by debates around the motion of social capital. Trust has been identified as a major factor influencing such thing as capital investment, relationship marketing, cross-cultural communication, learning and various types of cooperation. Trust management become also very important inside organization. The study will examine empirical research on organizational trust inside organization in opinion of polish managers. The research was done in 163 polish enterprises among 335 managers.

Key words: trust management, organizational trust, building trust

INTRODUCTION

Trust is a topic that has been studied a lot lately. The world in which we live has become extremely interdependent. Extremely high uncertainty has become the institutional context of postmodern societies, and therefore there is great need for trust and social capital. Trust enables people to live in risky and uncertain situations (Deutsch, 1962; Mayer et al., 1995). It provides the means to decrease complexity in a complex world by reducing the number of options one has to consider in a given situation (Luhmann, 1979; Barber, 1983; Lewis and Weigert, 1985). Trust can also be viewed as a kind of social capital that makes coordination and cooperation between people possible (Putnam, 1995; Misztal, 1996). Trust leads to successful relationships and improves communication and satisfaction (Anderson and Narus 1990; Doney and Canon 1997; Mohr and Nevin 1990; Morgan and Hunt 1994). It binds friendships (Gibbons, 2004), facilitates negotiations (Olekalns, Smith 2005), and even resolves international political conflicts (Kelman, 2005). It is a fundamental ingredient in any positive and productive social process. In the world of business, trust is key to successful transactions and long-term relationships (Bharadwaj, Matsuno 2006; Koehn, 1996). It has even been proposed as an alternative form of control in place of price and authority (Creed and Miles, 1996).

Within organizational settings, trust has been demonstrated to be an important predictor of outcomes such as cooperative behavior (Zalabak, Ellis, Winograd, 2000), organizational citizenship behavior (Van Dyne, Vandewalle, Kostova, Latham, Cummings, 2000), organizational commitment (Aryee, Budhwar, Chen, 2002), effectiveness in organization (Zand, 1972; Zand, 1997; Lewis and Weigert, 1985; McAllister, 1995; Lane, 1998; Rousseau

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et al., 1998; Nooteboom, 2002), and employee loyalty (Costigan, Ilter, Berman, 1998). To build employees' trust in an organization should be a desirable goal for all employers (Zhang, Tsui, Song, Ch, Jia 2008).

The aim of the article is to define elements of the trust in organization, which influence on trust building among managers and subordinates and to present conclusions from the research connected with this topic, made in polish enterprises.

CONCEPTUAL BACKGROUND OF TRUST

Trust as an individual future

Viewed from the individual level, trust is best understood by looking at the psychology of the person. Such a perspective can explain why a person trusts and why trust declines or increases (Tyler & Kramer, 1996). Personality psychologists such as Wrightsman (1966) and Rotter (1967) have viewed trust as a personality trait that reflects the general expectancies of the trustworthiness of others. These expectancies are relatively stable dispositional characteristics that depend on personal experiences and previous socialization. This observation also confirms Luhmann (1979). According to him risk and some information about the potentially trusted person or situation are seen as necessary conditions for trust to exist. J.R. Gibb (1978) a psychologist has created theory that trust is instinctive, and, as a feeling, is so close to love. Trust is also regarded as an attitude, which is neither subjective nor objective, and does not simply involve mechanical influences from the environment since it has to be learned (Luhmann, 1979). Viewing trust as a psychological state implies that people vary in terms of when and how much they are willing to trust (Das & Teng, 2004). Such willingness to trust, according to Tyler and Kramer (1996), is based on people's estimation of the probability that those trusted will reciprocate the trust.

Trust as a part of relationship

Lewis and Weigert (1985) stress that individuals would have no occasion or need to trust apart from their relationships with others. This assertion emphasizes the sociological function of trust instead of its supposed psychological function. Trust is an essential ingredient in the initiation and maintenance of stable social relations, just as exchange obligations promote trust (Blau, 1964). Barber (1983) identifies three kinds of expectations in relation to trust: (1) an expectation of the persistence and fulfillment of the natural and social order, (2) an expectation of the technically competent role performance from those involved with an individual in social relationships, and (3) an expectation that partners in interactions will carry out their fiduciary obligations and responsibilities. The three presented perspectives on trust as an expectation highlight trustors' beliefs that the trustees are good and honest in dealing with the goods, material or non-material, entrusted to them despite their ability to cheat or betray the trustors. Trust is partially a product of people's capacity to assess the trust- worthiness of their potential partners (Sheppard & Sherman, 1998).

Commonly, trust has been viewed as an expression of confidence between the partners in an exchange or a relationship of some kind (Bateson, 1988; Garbarino and Johnson 1999), a

belief that no partner to the exchange will exploit the other's vulnerability (Dwyer and Oh, 1987), or the willingness to rely on the other party (Moorman, Deshpandt, and Zaltman 1993). Similarly, trust has been defined as positive expectations about another party's motives in situations entailing risk (Das and Teng 1998).

Lindskold suggests that there are four different kinds of trust, which exist in any relationship. These relate to the following:

- objective credibility (It can be viewed in terms of whether that person's or group memebrs' words can be believed, and whether their actions correspond with their words);
- the attribution of benevolence (examines the motives of an individual's actions);
- non-manipulation (based on the perceived level of self interest of the party);
- costs for lying (balances the costs of deceit against the possible gains).

In organization trust facilitates more open communication, information sharing and conflict management. Trust is believed to be critical as it is seen to increase predictability, adaptability, and strategic flexibility. In general trust is seen to reduce transaction costs such as management costs, internationalization costs, social complexity. It also paves the way for informal network collaboration and collaborative innovation. It is also acknowledged that trust may be a critical factor in enhancing business performance and a source of sustainable competitive advantage (Seppanen, Blomqvist, Sundqvist, 2007).

Trust is not static; it is a dynamic process that evolves according to the development of the relationship (Porras, 2004). Lewicki and Bunker (1996) established a model of trust in three levels linked in a sequence where, once trust has been established in one level, it moves to the next level. Those levels of trust are calculus-based, knowledge-based, and identification-based. At the calculus-based level, parties fear punishment, but also anticipate the rewards from preserving trust; in other words, trust is based on a calculus of costs and benefits. Knowledge-based trust develops over time in the permanent contact between participants; it is "grounded in the other's predictability - knowing the other sufficiently well so that the other's behaviour is anticipatable. Knowledge-based trust relies on information rather than deterrence" (Lewicki, Bunker, 1996). Identification-based trust is "based on identification with the other's desires and intentions" (Lewicki, Bunker, 1996). At this stage, parties know each other and may anticipate the reactions of the other participant; thus, they can act for the other. Ultimately, high trust implies an expectation that a relationship will continue in the future.

Trust is highly relevant when the trustor depends on the trustee's future action(s) to achieve her own goals and objectives (Lane, 1998). For trust to develop, it is required that the trustee does not indulge in opportunistic behaviour, so that the trustor can put herself in a vulnerable position with regard to the action(s) of the trustee. This requires a stable normative frame. In other words, for trust to be possible, the trustor needs to believe that the trustee wishes to continue the relationship into the future (Lindenberg, 2000; Hardin, 2002).

For interpersonal trust to be built in long-term work relations, both individuals need to have their actions guided by a stable normative frame. According to Six (Six, 2007) there are four operative conditions that play an essential role in stabilizing normative frames:
(1) the suspension of opportunistic behaviour, or the removal of distrust;
(2) exchange of positive relational signals;
(3) avoiding negative relational signals, i.e., dealing with trouble;
(4) the stimulation of frame resonance, or the introduction of trust-enhancing organizational policies.

An organization needs to ensure all four conditions, but depending on the particular environment it operates in, the emphasis may differ. The more an organization meets all four conditions, the more likely it is that interpersonal trust can be built successfully in the work relations within it (Six, 2007).

Trust as a part of social and economic exchange

Trust is essential in economic and social exchange. According to Blau (1964) social exchange is the voluntary action of individuals who are motivated by the returns they are expected to bring and typically do in fact bring from others. He wrote that the benefits involved in social exchange are not definitively priced in terms of a single quantitative medium of exchange. This is the reason why obligations in social exchanges are not specific, while economic exchanges are moored on a formal contract that specifies the exact amount to be exchanged. Though both exchanges conceptually differ, both depend on trust for their continuation (Buskens, 1998; Doney et al., 1998; James, 2002), and both exchanges involved varying amounts of uncertainty and risks (Molm, Takahashi, Peterson, 2000).

Viewed from an economic standpoint, trust is an expectation that people will not be exploited by others, which exists when there are no strong incentives for people to behave opportunistically (James, 2002). Hosmer (1995) refers to trust as the reliance by one person, group, or firm upon a voluntarily accepted duty on the part of another person, group, or firm to recognize and protect the rights and interests of all parties engaged in a cooperative endeavor or economic exchange. According to Anderson and Naurus (1990) trust is the firm' belief that another company will perform actions that will result in positive outcomes for the firms as well as not take unexpected actions that result in negative outcomes.
Tullberg (2008) argues that in most economic exchanges, not everything can be verified before the occurrence of a transaction, thereby making the elimination of risks impossible and thereby necessitating trust. For example, within marketing, customers need to determine the extent to which they trust the company and its personnel to make purchases and long-term relational commitments (Doney & Cannon, 1997). According to M. Sako (1992) trust can be treated as a state of mind, an expectation held by one trading partner about another, that the other behaves or responds in a predictable and mutually acceptable manner.

The concept of trust can be explain in different ways for example as an individual future, as apart of relationship and as a part of economic and social exchange, also we can look at definition of trust in different disciplines. For example, the economists define it as trusting the institutions and their accounts while the psychologists explain it with the reliable and

unreliable behaviour of the individual and the sociologists use it as the reliable, fair and ethical behaviour in interpersonal relations. Author (Paliszkiewicz, 2010) see trust as the belief that another party: a) will not act in a way that is harmful to the trusting firm, b) will act in such a way that it is beneficial to the trusting firm, and c) will act reliably d) will behave or respond in a predictable and mutually acceptable manner. Trust can be seen as a bridge between past experiences and anticipated future.

THE STRUCTURE OF TRUST

Trust has emerged as a critical construct in a variety of disciplines, and, as a result, there exist several different conceptualizations of the structure of trust.

Despite its importance in organizational research, the study of trust has not been without problems. There have been some inconsistencies in the conceptualization and measurement of trust in previous research (Bigley, Pearce, 1998; Dirks, Ferrin, 2002). The most serious criticism is the lack of agreement about the structure of trust, and in particular the inability of researchers to distinguish between the antecedents and the construct of trust itself (Bhattacharya, Devinney, Pillutla, 1998; Mayer, Davis, Schoorman, 1995). For example, Costa, Roe, and Taillieu (2001) conceptualized trust as a multi-component variable with three distinct but interrelated dimensions. These dimensions consist of propensity to trust, perceived trustworthiness, and cooperative and monitoring behaviors. This definition includes a dispositional variable, propensity to trust, as well as cognitive and behavioral dimensions. In order for the field to move forward, it is imperative that researchers maintain a clear conceptual distinction between propensity to trust, defined as an individual's general willingness to trust others, and actual trust or trusting behaviors (Mayer et al., 1995).

Variations in propensity to trust among people can be attributed to their developmental experiences, personality types, and cultural backgrounds (Mayer et al., 1995). Trusting propensity or trusting impulse could be specific or general – it could refer to a specific category of people or it could encompass all people (Sztompka, 1999).

As a stable factor, trust determines the likelihood that people will trust, just as it influences how much they trust others prior to the availability of any data about them (Mayer et al., 1995). Rotter (1971) argues that people's propensity to trust influences their levels of trust in their interactional partners, especially in cases when the former has limited knowledge about the latter.

In the model of initial trust formation by McKnight, Cummings, and Chervany (1998), propensity or disposition to trust is proposed to be one of the determinants of trusting intention. They identify two types of disposition to trust: faith in humanity and trusting stance. Faith in humanity refers to the belief that others are well- meaning and reliable; whereas trusting stance means that people believe that they will obtain better interpersonal outcomes by dealing with others as though they are well-meaning and reliable, regardless of whether those others are reliable or not.

McKnight, Choudhoury, and Kacmar (2002) define trusting intention as people's willingness

or intention to depend on their interactional partners. Willingness to depend (volitional prepared- ness to make oneself vulnerable to the trustee) and subjective probability of depending (perceived likelihood that one will depend on the other) form two distinct subconstructs of trusting intention.

Mayer et al. (1995) proposed the Integrative Model of Organizational Trust, a theoretical framework examining trust in an organizational setting involving two individuals: a trustor (the individual trusting) and a trustee (the individual being trusted). In their model, trust is defined as "the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer et al., p. 712). Mayer et al.'s definition of trust has become widely accepted in the organizational literature (e.g., Rousseau, Sitkin, Burt, Camerer, 1998). Unlike past conceptualizations of trust, this definition separates trust from its antecedents. In Mayer et al.'s (1995) model, both the disposition of the trustor and the perceived characteristics of the trustee influence trust. According to this model, trust does not involve risk per se, but rather a willingness to engage in risk-taking with the trustee (e.g., sharing sensitive information). Thus, trust represents an intention to take a risk in a relationship.

In assessing the trustworthiness of interaction partners, people can use a set of criteria to come with a reliable assessment. These criteria or factors of trustworthiness (Mayer et al., 1995) include ability or competence (Barber, 1983; Luhmann, 1979; Mayer et al., 1995; McKnight et al., 1998), benevolence (Luhmann, 1979; Mayer et al., 1995; McKnight et al., 1998), integrity or honesty (Mayer et al., 1995; McKnight et al., 1998).

Based on the characterization of Mayer et al. (1995), parties in transactions are assessed to be trustworthy when they (1) have the required skills, competencies, and characteristics that enable them to exert influence within a specific domain – a description for the ability or competence criterion, (2) are believed to do good to trustors, setting aside an egocentric motive – thereby meeting the benevolence criterion, and (3) are perceived to adhere to a set of principles that trustors consider acceptable – a definition of integrity.

Sztompka (1999) also claims that people employ three criteria in estimating the trustworthiness of their transactional partners: reputation, performance, and appearance. Reputation refers to a record of past deeds; whereas, performance includes actual deeds, present conduct, and currently obtained results. Appearance also matters as one's look and self-presentation can exude trustworthiness or stimulate suspicion on the part of the looker. In the literature we can find also different models of trust a lot of them are static or take the perspective of the trustor only (for example, Mayer, Davis, Schoormann 1995). Zand (Zand 1972) is one of the few who propose a truly interactive model: "Let P denote one person and O the other. If (1) P lacks trust, (2) he will disclose little relevant or accurate information, be unwilling to share influence, and will attempt to control O. (3) Assume O also lacks trust, (4) perceives P's initial behaviour as actually untrusting, and (5) concludes he was right to expect P to be untrustworthy; then (6) he will feel justified in his mistrust of P. Since (7) P sees O's behaviour as untrusting, he (8) will reinforced in his initial expectation that O would not be trustworthy and (2) P will behave with less trust than when he entered."

Some features of trust were presented by A. Argandoňa (1999):

- It is interpersonal: between concrete individuals;
- Situational rather than global: trust is placed in one particular person;
- Voluntary: properly, trust must spring from choice and cannot be compulsory;
- Fee, since no party can (sufficiently) control the other party's behavior;
- Committed, since each party depends on the other (without being able to control her);
- Conscious: each party is aware of the other party's trust;
- Vulnerable, because betrayal or breach of trust are possible;
- Relevant, in the sense that the consequences of breach of trust by one of the parties cannot be considered insignificant by the other;
- Dynamic or temporal, because it evolves over time: trust is established, grows, diminishes and dies;
- Action oriented, implicit in the goal of the alliance;
- Uncertain, since before the alliance is established it is possible to question the reliability of the other party and, once it is under way, the question is whether the other party will have change of heart and betray the terms of the relationship;
- Based on communication, and
- Experimental.

Bidault and Jarillo (1997) argue that trust can be based on different sources. Contract establish a foundation for developing trust; ethics provides rules and values for actors to behave in different circumstances; the role of time and experience is important because trust increases with the number of transactions made by participants while familiarity relates to participants knowing each other before a transaction. Bidault and Jarillo (1997) consider trust as a coordinating mechanism that can make transactions cheaper, in the sense that, once trust has been established, contracts will not be needed between participants.

Nicholson, Compeau, Sethi (2001) define trust as confidence in the other party's reliability and integrity. Recently, some researchers in marketing have suggested that in addition to integrity and reliability (which they equate with credibility), trust also consists of a benevolence dimension (Ganesan, 1994; Kumar, Scheer, Steenkamp, 1995). A closer examination of the benevolence dimension reveals that it encompasses both friendship between partners and making sacrifices for the other partner (Ganesan, 1994). McKnight, Cummings, and Chervany (1998) also suggest that trust consists of two main dimensions: trusting intentions (i.e., willingness to depend on other) and trusting beliefs (i.e., believing that the other is benevolent and honest).

TRUST IN ORGANIZATIONS IN OPINION OF POLISH MANAGERS

The research was done in enterprises from Mazovia Province. The questionnaire was done among 335 managers from 163 companies from November 2010 to February 2011. The enterprises are the best enterprises according to Journal Forbes in Mazovia Province.
According to the author trust in organization consists of reliability, intention and abilities (Figure 1).

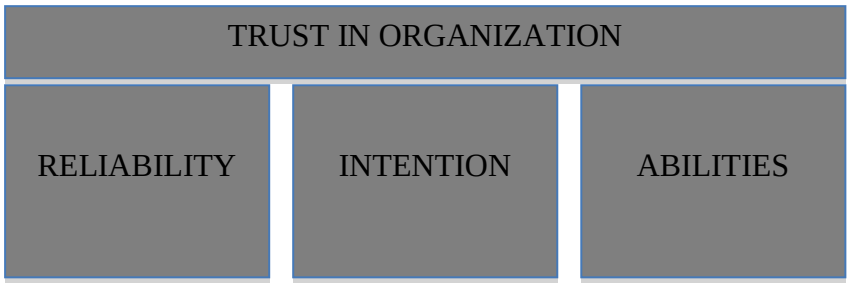

Figure 1: The model of trust in organization.
Source: Author's research

Reliable means capable of being relied on. In the table 1 there are presented questions which were used to check opinion of managers about reliability in organization. The possible answers for the questions were: 1 - I strongly disagree, 2 - I disagree, 3 - I do not know, 4 - I agree, 5 - I strongly agree.

Table 1: Questions connected with reliability.

No	Reliability
1.	I trust my subordinates
2.	All employees are treated fairly
3.	Company cares about employees' interests
4.	Most people in company keeps promises
5.	People in company avoid the gossip and participation in an unfair criticism of others
6.	In company there are good relations between employees

Source: Author's research

After suming a points, the answers were divided into three groups. The best from 23 to 30 points, the medium from 15-22, and the weak from 6–14 points. The results are presented in table 2.

Table 2: Level of reliability.

Groups	Group I 23-30 points	Group II 15-22 points	Group III 6-14 points
Number of managers (in%)	52%	47%	1%

Source: Author's research

According to opinion of managers, 52% of them have a very good opinion about reliability in their organizations, 47% medium and only 1% weak.

The next element of trust in organization is intention. Intention is a course of action that one intends to follow. In table 3 there are presented question, which were used to check opinion of managers about intention in opinion of managers. The possible answers for the questions were: 1 - I strongly disagree, 2 - I disagree, 3 - I do not know, 4 - I agree, 5 - I strongly agree.

In this case the best answer for organization have 5 points, so the answer for the questions from 1 to 5, were accounting as follows: if the answer was 1 it has 5 points, for the answer 2 – 4 points, for the answer 3 it was 3, for answer 4 it was 2 points, and for an answer 5 – one point.

Table 3: Questions connected with intentions.

No	Intentions
1.	In dealing with others, people never should be too careful
2.	You should not trust other people until you do not know them well
3.	Most people will lie if it enable then to get something
4.	Employees in your company when the opportunity arises to gain something will be dishonest
5.	In these days in your company you can only count on yourself and only trust yourself
6.	In your company employees can openly talk about what they do not like, or how something should be changed

Source: Author's research

After suming a points, the answer were divided into three group as in the first case. The best group from 23 to 30 points, the medium group from 15-22, and the weak group from 6 – 14 points. The results are presented in table 4.

Table 4: Level of intentions.

Groups	Group I 23-30 points	Group II 15-22 points	Group III 6-14 points
Number of managers (in%)	20%	70%	9%

Source: Author's research

According to opinion of managers, 20% of them have very good opinion about intentions in their organizations, 70% medium and only 9% weak.

The next elements of trust in organization are abilities. Ability is the group of skills, competencies and characteristics that enable a party to have influence within some specific domain. In table 5 there are presented question, which were used to check opinion about abilities. The possible answers for the questions were: 1 - I strongly disagree, 2 - I disagree, 3 - I do not know, 4 - I agree, 5 - I strongly agree.

Table 5: Questions connected with abilities.

No	Trust: Building abilities
1.	In the company managers are primarily advisors and intellectual partners to subordinates
2.	In your company results are most important, the main concern is how to do the best tasks, the employees are very ambitious and driven to achieve
3.	Your company is implementing new ideas and improving work conditions
4.	In your company your employees feel accountable for their tasks and do not have to be monitored
5.	In your company staff for most of the time trying to be helpful to others and do not care only about self-interest
6.	Your company prefers a stand-alone risk-taking, innovation, originality

Source: Author's research

After suming a points, the answer were divided also in three groups as in the other cases. The results are presented in table 6.

Table 6: Opinion about abilities.

Groups	Group I 23-30 points	Group II 15-22 points	Group III 6-14 points
Number of managers (in%)	40%	58%	2%

Source: Author's research

According to opinion of managers, 40% of them have a very good opinion about abilities connected with trust in their organizations, 58% medium and only 2% weak.

At the end of analysis all elements were bring together and the level of trust was account. The results are presented in table 7.

Table 7: Level of trust according to opinion of managers.

Groups	66-90	42-65	18-41
Number of managers (in %)	**37%**	**63%**	**0%**

Source: Author's research

Among researched managers, most of them present medium level of trust – 63%. Very high level was identified in the group of 37% of managers. No one of them was in the worst group.
The research was done in the best enterprises, so maybe that is way the managers present so high scores and the good level of trust.

CONCLUSIONS, LIMITATIONS AND MANAGERIAL IMPLICATION

There are several reasons why the research of trust has long remained problematic. First of all, there has been lack of clarity of the key concepts such as trust and risk. The antecedents and outcomes of trust have also been blurred and the roles of trustor and trustee haven't been clear enough. Perhaps the interdisciplinary interest in trust is one of the reasons why

the concept of trust lacks clarity. Since trust research has spread to several disciplines, a single researcher needs to collect the bits and pieces of trust related studies in various disciplines and try to make his or her synthesis to add something new to the scientific discussion of trust. However, for a new researcher, trust as a research topic gives many possibilities. For example, trust is also one of the key concepts in the knowledge-based competition of the network era and has been kindly studied recently in computer science related areas. New technologies have raised the interest in trust all around the world. Examples of currently researched topics are studies questioning what make consumers trust a certain webside and how trust can be built in online buyer-seller relationships.

Several limitations to the proposed theory should be recognized. First, the theory presented here is limited to trust declared by managers to subordinates and further research is needed to extend it to other forms of trust such as trust in organizations or trust among all members of organizations. A second limitation is that the article focused on work relations within organizations, and the research was done only in the best enterprises.

The research contributes to the understanding of trust by proposing the method of measurement. The findings of the current study have implications for organizations. Some recent changes in the workplace, such as an increase in the use of project-based and virtual teams, require employees to form new cooperative relationships quickly, often based on limited information about the coworkers. Given this new reality, it is important for researchers and practitioners alike to explore how trust forms initially, and how it can be maintained over time. The interplay between perceptual and dispositional factors, the focus of the current research, represents one way for research that could be fruitful in gaining a better understanding of trust.

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EXPLORING TRUST DEVELOPMENT IN MANAGEMENT STRATEGY WORK: AN INNOVATIVE WAY OF STUDYING AND FINDINGS FROM QUALITATIVE STUDIES

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ABSTRACT

This paper aims to bring the view of management innovations in organizations into discussion by presenting an innovative way and framework of exploring management strategy process from the perspective of trust development in strategy work. Trust in managerial leadership is seen as intangible, intellectual capital. It is defined as a skill, way of leading, and power for influencing. A more specific question is how trust develops in the strategy work of the top management.

This paper reports of a study - in early progress towards doctoral dissertation – that explores trust development in the strategy process at the top management level. As the perspective of trust and development of trust in strategy process (formation) are very scarcely studied so far both theoretically and empirically, the paper discusses and outlines a theoretical frame for studying trust in the strategy process. Preliminary findings based on qualitative data from top managers are presented.

Keywords: strategy process, strategy work, trust, ideology, strategy discourse

THEORETICAL FRAME OF THE STUDY

Introduction

Strategy work and trust development

In the paper, strategy work is conceptualized according to the well known model by De Wit & Meyer (2005, 8). Moreover, trust and the process of trust development in strategy work are explored from the relational perspective (Mayer et al., 1995). In other words, trust is seen to develop (be formed, sustained, and restored) in discursive interaction between organizational actors. Knowledge management, and sharing in particular, is linked to trust formation (Savolainen, 2008). Knowledge is ideological in nature and sharing at least partly relational in the sense of trust development. The aim of strategy and strategy work is commonly organizational change or transformation (De Wit & Meyer, 2005).

Knowledge transfer and sharing, trust, and strategy work are all constructed socially in discursive interaction at the boundary surfaces where innovations are developed as well. That is why discursive practices may provide answers to the question about the role of trust

and how trust develops in strategy work between top level managerial actors. Discourse is not only a language for strategic thinking or knowledge sharing per se but an action which, in turn, changes discourse, and goals, models and schemas, accordingly (Sveiby, 2010: De Wit et al., 2005; Ståhle et al., 2002; Kerttula, 2010).

Trust in managerial leadership is seen as intangible, intellectual capital. It is defined as a skill, way of leading, and power for influencing (Savolainen, 2010). Knowledge sharing is also discussed as related to trust and leadership in strategy making.

Cooperation between organizational actors faces increasing future challenges in building sustaining trusting relationships within and between organizations. Successful relationships are seen to enable organizations to cope with levels of uncertainty in times of changes (Atkinson, 2004)

Trust is dynamic, volatile and contextual in nature (Lewicki, Tomlison & Gillespie, 2006, 992). The attributes of uncertainty, complexity and risk describes the concept. Trust involves a risk to become betrayed or wounded despite of the positive endeavours of trust in developing openness, and effective co-operation (Savolainen, 2010; Mayer, Davis, & Schoorman, 2005). Uncertainty originates from the risk and expectations (Savolainen 2008, 3). Trust is about taking risk (McAllister, 1995, 184) and involves willingness to take risk (Mayer et al., 1995). Thereby trust is exposed to blindness and deceptive action (Nooteboom, 2003, 1). Activities are based on knowledge, knowing and especially exploitation. Trust is 'fragile' and can be broken easily (Savolainen & Ikonen, 2010, 2).

Trust is built in the course of time and of compatible words and actions (Mishra 1996, 268, Lewicki & Bunker, 1996, 119). In addition trust is based on mutual, legal and psychological agreements. Trust development is a process and a psychological state (cf. Kramer, 1999, 571) and functional state with different phases and levels. The process seems complex, non-linear, and non-straight forward with more of a wave like development with (Laaksonen, 2010; Savolainen, 2010b; Ikonen & Savolainen, 2010). McAllister (1995) have provided evidence for the fact that trust has cognitive and affective aspects (Lewis & Weigert, 1985). Trust can be founded on emotions and cognition of an actor. Cognition-based trust expresses rationalism and knowledge (McAllister, 1996, 25-26).

Researchers have suggested models comprising stages (Lewicki & Bunker, 1995, 1996) and interactive processes of trust development (McAllister, Lewicki & Chaturvedi, 2006, 1). According to Lewicki and Bunker (1996, 120) trust develops in three stages. They call the stages as follows: calculus- based trust, knowledge-based trust and identification-based trust. The model is a linear type of progressive model and is criticized and questioned among others by Savolainen (2008, 2010), Ikonen and Savolainen (2010). In addition McAllister (1995) argues that trust develops contextually based on cognition and emotions. Savolainen (2009) has integrated model of trust development by Lewicki & Bunker (1996) and LMX-theory of leadership development by Graen & Uhl-Biem (1995). According to Savolainen (2009, 4) integrated model of trust development includes following phases such as convenience, acquaintance and matured partnership phases.

Top managers play a key role in strengthening strategic competitiveness of the organization. They are not only influenced by other actors but also their own "black boxes" which may limit or stimulate their thoughts and ideologies. It is to be asked, what happens in reality in the manager's strategic thinking and action processes, and how it is related to and appears in trust development within TMT and between team members.
The top management is influenced by multiple actors and parties not only in side of the organization but outside during the strategy process as well. However, a top manager is exposed to different kinds of beliefs, ideologies, paradigms, schemas and mental maps, dominant logics and personal abilities in strategic management and leadership processes. In strategic thinking, this has an influence on the management. Additionally, it should be noticed that the thinking, reasoning and decision making of top management is restricted by their mental abilities (De Wit & Meyer, 2005).

In addition, top management is acting as an agent as explained in the agency theory. There is a remarkable risk of the conflict of interests which may have impact not only on strategic thinking and strategy forming but on strategic change as well. This aspect cannot be disregarded in interpreting the top management discourse considering how trust is developed in a strategy process.

TMT strategy work and innovations

Top management members emphasize innovation as one of the most important issue in the strategy work. Business Week´s annual survey of TMT in 2010 reported that 83 percent of TMT members said that "innovation will be a key part of our strategy". In addition they argued for innovation as a "top three strategy priorities" (Andrew, 2010).

Innovation is defined from different perspectives and thereof more explicit definition is required in this paper. As trust and trust development has not studied in the context of strategy work, particularly, using the concept of ideology as a research setting is ultimately innovative in its nature.

An innovative organization renews itself inside out as if itself (Ståhle et al., 2002). According to classical perspective innovation seeks technical or process improvement in order to boost efficiency and productivity (Roger, 2003). However, innovation is not only rational but also creative process in social and interactive context. Innovation consists of new idea, perspective, solution, way of working, or product. (Ståhle, 2002, 108).

Extension of definition indicates also importance of intellectual and social and human capital. Innovation develops at boundary surfaces where knowledge, interests, perspectives, ideas, procedures, and competences meet in an interaction. Thereof bases for innovation are laid on intellectual or human or social capital of people because social discourse and interaction gives birth to innovation. (Roger, 2003; Ståhle, 2002).

Knowledge based theory challenges classical innovation theory as knowledge is according to Sveiby (2010) alternative to product and competitive strategies as drivers of growth. Theory leads to be dependant of relationships and learning (knowledge). People are the actors. Value creating takes place when they transfer or convert knowledge either internally or

externally in interaction (Sveiby, 2010). Sveiby argues that value grows every single time when people transfer or convert knowledge. There has to be knowledge as much as possible,that is value free, for the ground of innovation (Sthåle, 2002). Interaction adds knowledge, and it is where people use their capacity and competence.

As knowledge is according to Polanyi (1958; Sveiby, 2010) private or personal or even beliefs with meanings the worlds are constructed in subjective system, and which does not represent common reality. That reality can be seen in actions of the actor. That leads to individual competence, capacity-to-act, in changing situations.

Interaction, and particularly discourse, between actors is vital not only for formation of strategy, transferring knowledge and developing trust but for developing innovations and ideologies as well. Innovative way of exploring trust development in the strategy work is to study that phenomenon from a perspective of developing ideologies and as ideology.

The concept of ideology is applied to top management strategic thinking presuming that a managerial ideology and reality are formed of intellectual, mental and ideological concepts. By them are meant cognitive, psychological and influencing processes through which reality with meanings are constructed in dynamically changing situations (cf. Gubrium & Holsten, 2000, 487; Savolainen, 1997). That is why in the research setting of the paper, trust development is suggested to be ideological in nature developing through analytical process of knowing and intending, a cognitive process of strategic thinking and reasoning for sense-making, and a psychological influencing process for building and sustaining trust. Within these processes constructed reality is an emerging process of communication and discourse.

Concept of ideology

The concept of ideology in organizational management (Savolainen, 1997) has been developed further and used appropriately in interpretation. Ideas are determined by a society. According to Boas (1973) ideas may born randomly or few have thought, written or discussed about them. Ideas may be pounded together by a logic or thematic coherence. In the discursive environment, ideas may emerge, grow and flourish, wither and mold or ultimately die. (Savolainen, 1997, 128).

Ideologies spread by authors propagating them. Secondly adopters embrace or become interested in the idea, ideology or doctrine. Ideology may model people´s mind, thinking and behavior. Finally ideologies may obtain canon. Ideologies may saturate to usable knowledge. The manager's black box is affected by three views being at the same time nested as following (Figure. 1.): intellectual, mental, and ideological views. The reality is constructed in interaction with these three views.

First of all, people can commonly think within adopted doctrines, paradigms or models. This intellectual view is called an analytical process of knowing and intending. Intellectual view shapes the ideology, that is to say, trust development in this case. The intellectual view includes dogmas, paradigms and models. Secondly, people are not only intellectual beings but they have mental views as well. That is a cognitive process of strategic thinking and

reasoning for sense-making including cognitions, abilities and mind-maps for driving the trust development. This view includes, for example, mind maps, schemas, dominant logics, beliefs, assumptions etc., which are learned by education, and also tools used. Thirdly the ideological view is a psychological influencing process for building and sustaining trust. That has activities, effects, influences (power-games) and consequences.

Figure 1: Trust development in TMT strategy process.

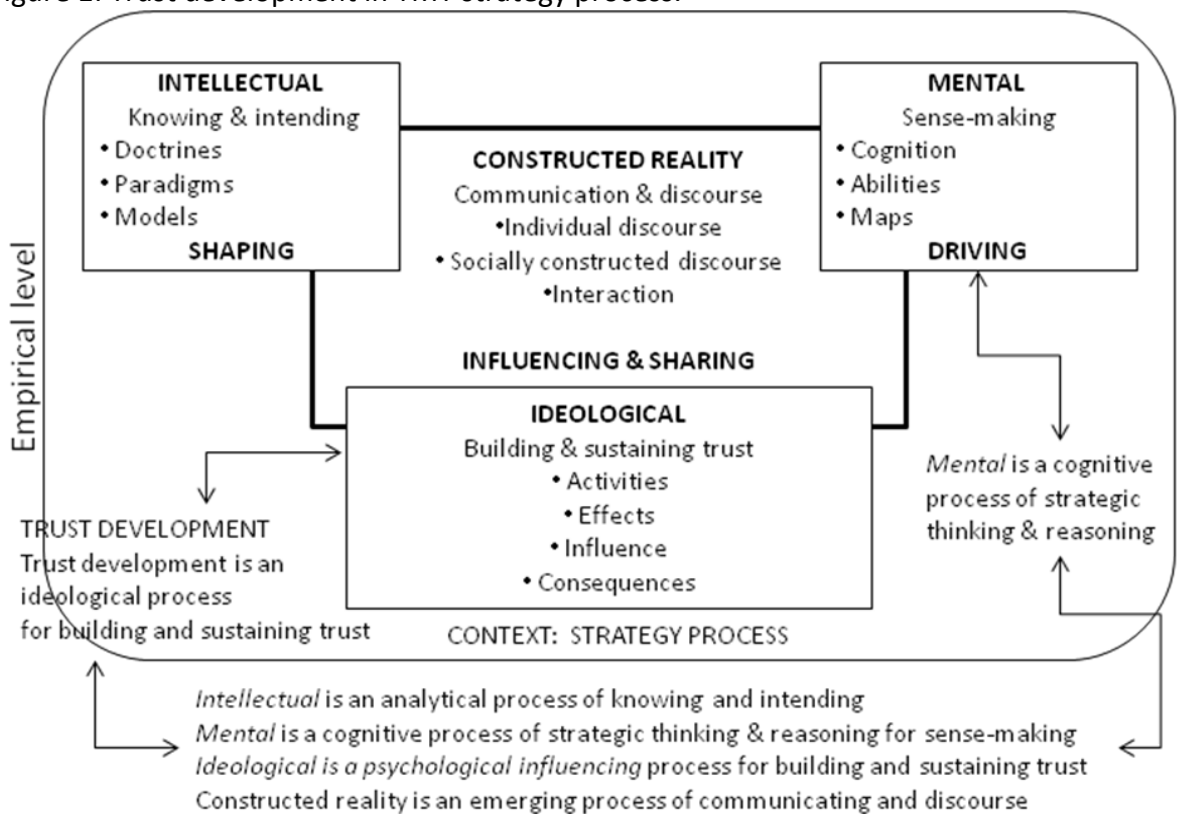

Figure 1. Framework of the study: Trust development in TMT strategy process (adapted from Savolainen (1997); elaborated by Kinnunen)

Empirical study and its findings support specific innovative trust development model, trust as psychological influencing process. As following specific issues from chosen cases are presented for support of concept.

RESEARCH METHODOLOGY AND DATA

The paper describes chosen case-reports based on empirical studies made in companies operating in health care, and media, and development aid industries. The health care company, case A, was in an internationalization process from domestic to Nordic. The media company, case B, was in a financial crises coping with turmoil, and the development aid organizations was in a change of leadership and management systems.

Secondary information and data were collected using participatory discussions, interviewing and observing the top management team members, MDs and CEOs. Data includes notes from interviews, researcher´s diary notes, made by the researcher acting as management member, and written distributed strategy material. The data is used to sett research frame

of the study - in early progress towards doctoral dissertation – in order to clarify pre-understanding of the phenomenon. Primary data will be analysed in order to explore trust and trust development as ideological process.

Figure 2: Sources of data by cases

	Sources of Data	Case A	Case B	Case C
1.	Senior management and CEO discussions/interviews	2	1	1
2.	Managing director/Business director discussions/interviews	10	4	5
3.	Management & leadership observation	20	10	5
4.	Strategy document analyses	5	2	5

Figure 2. describes the sources of data according to the cases and sources.

In summary, there are three conceptual views combined in Figure 1. Each view is actualized in interaction in constructed reality inducing to a new ideological understanding of trust development. Constructed reality is an emerging process of communication and discourse including sharing and influencing. Reality is constructed based on intellectual and mental, cognitive processes (visible or invisible realities) forming into ideologies. This leads the development of trust to emerge in the context of strategy process.

The management strategy work should be done, using participatory methods involving all key managers (cf. Mantere & Vaara). In each case the purpose of strategy meetings was strategy work including strategic thinking and strategy formation in order to manage strategic changes in each organization.

The themes of analyses were made, focused on trust and trust development from different perspectives. The research questions are formulated as following.

How does trust appear in the strategy process?

Two other questions have been asked for empirical analysis.

What processes and factors are related to trust development?

How does trust emerge and develop in the course of the strategy process?

Findings are presented according to issues found to be critical in trust and trust development in the context of strategy work.

PRELIMINARY FINDINGS

Intellectual factors shape knowing and intending

People can commonly think within adopted doctrines, paradigms or models (De Wit et al., 2005). Intellectual view shapes the ideology, that is to say, trust development in this case. The intellectual view includes dogmas, paradigms and models.

Intellectual aspect appears when some model, doctrine or paradigm is used in the strategy thinking and formation processes such for example as strategy tools. In addition

perspectives in strategy work may influence dramatically in trust development. In the individual thinking and reasoning process it shapes strategy thinking. At the same time it limits knowing and intending according to the ideology of the model or doctrine used. Strategy work includes all kinds of important actions which aim to ensure the mission of the organization and thereof its existence. Moreover, discursive approaches of strategy work are success factors in terms of motivating ones participation. That is to say that intellectual, models, paradigms and doctrines, are realized in interactive and discursive strategy work including self-actualization, dialogization and concretization (Mantere & Vaara, 2008).

Organization is for certain purpose. Purpose-oriented organization is goal-driven with leadership pursuing to meet needs of people (cf. De Wit et al., 2005). However, perspectives of proceeding with strategy work may vary occasionally as cases indicate.

Intellectual view shapes the ideology, trust development in this case. The intellectual view includes dogmas, paradigms and models. Strategy work is called as analytical process of knowing and intending.

> Company A was in an internationalization phase from saturated domestic to fragmented Nordic markets. According to the model of corporate scope, in other words, company and corporate growth dimensions, it was decided to grow within business through horizontal integration and withdraw from not core businesses. That is called the concept of market development. (cf. De Wit et al., 2005). In the change, like that, it was asked various questions such as how should the expansion happen in terms of perspectives? What organizational systems are required to manage the company?
>
> Management knowing and intending was shaped by models, corporate doctrines and paradigms of corporate growth which consulting partners used. Strategy tools were used to shape intellectual capacity to focus on key issues. Used concepts gave common language, process and agendas for the strategy meetings (Stenfors, 2007; Kinnunen, 2008). For the post merger process of integration it was called various mixed groups and teams to work for strategic steps to manage change.
> Chosen tools gave process and language for strategizing it was found in the study, however, that these were critical hidden agendas individually and between management members. That shows importance of individual communication skills and especially courage to take leadership despite of different opinions. Due to unfriendly atmosphere some pulled out into capsule or grouped with sole mates in terms of strategic perspectives. After some time management members grouped according to perspectives of strategic thinking (logical vs. creative), and strategy formation (deliberated vs. emerged), and strategic change (radical vs. continuous) arguing for chosen perspective. That indicates power unbalance between members and also possibilities of power games in terms of organizational systems and own positioning. In addition this is a sign of ideological view based on intellectual knowing and intending process.
>
> Despite of sound intellectual aspects, high participation and drive for future vision trust development was not supported collectively in the social reality and

constructed discursive interaction. In other words, trust found different forms and ways to be grounded. Trust development was based trough common intellectual base like models, doctrines and paradigms used. The base provided language and agenda for a discourse and thereof opportunities for relational and professional interaction.

Findings indicate surprisingly that mixed management groups (lower, middle and top) did not realized expected integration in knowing and intending from the perspective of trust development between management groups. That may be due to the fact that management skills concerning particularly internationalization were poor and self-actualization, dialogization and concretization did not reached point of saturation. In other words, integration included too much mystification, disciplining and technologization (Mantere & Vaara, 2008) just because of poor strategic skills. That did not develop participation in reality which, in turn, hindered management dynamics.

This case challenges participation where members reach required level of competence and skills. However, in the case corporate strategy was implemented despite of distrust between some management members. Trust towards organization was firm due to promising future prospects and realized acquisitions. Strategy tools (theirs ideologies) provided common ground for discourse and relational interaction which, in turn, resulted into trustworthy shared vision. Vision as issues and ideology, however, joined parties together. Trust on vision was shaped by using intellectual process of knowing and intending.

Power balance between individual management members and the board of directors ended up to changes in management like rotation and out-soursing. In terms of years all management was changed for reason or another. Summing up reasons it seems that hesitation in strategic action and poor dynamics of strategic leadership may be main reason to created distrust on the management. In addition poor competence in communication, strategic management and, particularly, in internationalization seems to be reason to hesitation and poor dynamics of some management members.
Trust development was built on intellectual process of knowing and intending based on analytical approach. In other words, models, doctrines and management paradigms like strategy tools, processes, language, and management ideologies.

There are still other issues to be considered developing trust as power for influencing such as mental drivers and all together constructed reality.

Mental drivers and hindrances influence on strategic thinking and reasoning

People are not only intellectual beings but they have mental views as well (see figure 1.). That is a cognitive process of strategic thinking and reasoning for sense-making including cognitions, abilities and mind-maps for driving the trust development. This view includes, for example, mind maps, schemas, dominant logics, beliefs, assumptions etc., which are learned by education, and also supported by used strategy tools (cf. De Wit et al., 2005).

The Case B have evoked critical question concerning the perspective of trust development and knowledge transfer. From strategic point of view both issues are ranked drivers of sustainable growth and development (cf. Savolainen 2010, 2011). Both of them necessitate openness as key value.

Results show importance of hidden agendas and interest. Different mind maps, schemas, dominant logics, beliefs, assumption, which are base on earlier experiences and learned thinking and reasoning model, may have impact on strategic thinking and reasoning. Secondly it may drive strategy work and formation in such a manner that all aspects and perspectives are not taken under consideration due to conflict of individual interests or agendas. That is due to unbalance of power between members and one´ s capabilities in communication and argumentation. In addition individual ability to think may be limited not only due to knowledge or reasoning but because of self-interests in valuing strategic issues.
Satisfaction surveys are to be criticized because their results seem to communicate of power unbalance and capabilities in open discursive interaction. People work relatively open manner but, in turn, they seem not to trust without hesitation, and rather communicate anonymously.

> Results indicate that from mental perspective trust building is driven by strategic thinking and reasoning for sense-making in the context. Some times cognition, abilities and mind maps hinder trust development. On the other hand, they promote feelings and different views during the process of strategic thinking and reasoning, for sense-making, supporting trust development
>
> In addition in case companies were carried regularly employee satisfaction surveys. People answered to questions anonymously which encouraged answering in inconsiderately manner as well. However, a conflict was found between stated values of the organization concerning openness and methodology of the surveys encouraging secretive ways of communication.
>
> There was also conflict concerning knowledge transfer as value creation point of view. Such personnel satisfaction surveys introverted organization culture encouraging individualism and power games. The survey enforces informant to communicate in unripe manner which, in turn, does not create value and trust in a value network.
>
> Instead of using leverage to create value through knowledge transfer, communication and interaction management accepts a risk to be wounded by unspoken words and judgement. That does not develop trust either between team members or individuals. From strategy work and strategy formation point of view knowledge is vital and even crucial in building trustworthy stakeholders relations and strategies.
>
> Sveiby (2010) argues that the value grows every single time when knowledge is transferred and conversion takes place. Knowledge transfer develops competence and strengthens values acting of all parties. This perspective makes the issue of

methodology of current employee satisfaction surveys even more critical. Should the feedback be curried out at the round table or face-to-face? It is also to be asked, should the organization accept talking behind as a character of trustworthy culture. Instead there should be trust enabling innovative and creative culture.

Findings support the fact that feedback is not discussion without real communication at the presence of parties where all communication elements can be observed and used. In used satisfaction surveys there are hidden messages and make too much noise or provide misleading information as communication theory explains.

Mental is a cognitive process of strategic thinking & reasoning for sense-making. That is argued to evoke open and bipolar discursive interaction. Methods should support the goal of trustworthy culture.

Strategy work as constructed reality is sharing

In all cases change or transition took place as a result of new strategy. Karvonen (2003, 3-4) has argued that understanding and knowing depend on ones position. That is to say that world appears and gives meaning from the position of an observer. All information may change the social reality.

Knowledge arises in a dialog with data and researchers orbicular hermeneutics reasoning process. That means collecting data, discourse and observation, analysing written material and diary notes and interpreting case as holistic phenomenon.

Social life is a reproduction of an experienced world. Discourse is a reflection of a social life (Meyer, 2009, 38). The data from a social research object is already grouped and interpreted by the society. Thereof reality is socially constructed. That can be studied by analyzing meanings and implications of language as an awareness of a reality and shared meanings (Meyer, 2009, 38). In reality education and experiences are combined in actual situations. People make sense and give meanings to events they experience, which are often combined into previous experiences (Heikkilä & Holma, 1990, 24-25; Kerttula, 2009, 17).

Hence, people aim to analyze themselves as a part of the society. Various changes enable creative rethinking and sense-making (Kaplan & Maxwell, 1994). These discursive and interpretive approaches are in connection with the situation and methods used.

In the case C strategy work was carried in co-operation and highly participatory way. Communication and discourse were observed and analysed. Specifically agendas and mind maps (mental), models and doctrines (intellectual), and in different forms were observed. Strategic work happened in interaction and discursive communication using new strategy tools.

Findings suggest that strategy tools not only create the foundation for strategic thinking and discourse but also thereby support trust development and communication in TMTs through paradigms and ideologies (see also Kinnunen,

2008). Specifically, trust development is enhanced by the updated strategy tools and management procedures used. They have positive impact on the individual, dyadic, inter- and intra-organizational trust. On the other hand forcefulness given to strategy thinking and discursive leadership in the strategy process, strategy tools act in constructed reality, as an intermediary means between invisible thinking, and visible actions.

In addition to this, not only individual abilities and communicate but also power balances and reflections of the agent´s interests were considered. Those factors construct a reality of an individual manager. The reality is represented by the language and behavior, which are reflections of thoughts and environmental or situational determinants. As a reflection of trust, experienced by the manager, consequences can be seen in dynamics and behavior. In other words this is seen in hesitation and willingness to take action and to interact.

However, 'the other side of the coin' in the development in managers' professionalism has created distrust among sponsors and civil activist in some organizations studied. The findings show that changes in the development of 'professionalism' in top management over time has created distrust among sponsors, members and civil activist of the volunteer organization. The change has jeopardised the bases of values and funding activities. The change of drifting apart has affected the sponsorship and key partners.
In addition, the transformations from non-governmental organization to professional consulting organization, has increased distrust among highly active supporters. However, intellectual processes for knowing and intending were shaped not only by ideologies of the strategy tools and processes but also by doctrines.

In addition communication was driving, and at the same time hindering, mental processes of strategic thinking and reasoning. Each of cases showed that management has also its own agendas and interests which has an impact on dynamics and behaviour of a manager. That has a critical effect on trust development. It is question about human capital. Constructed reality is an emerging process of communicating and discourse

DISCUSSION AND CONCLUSIONS

First of all, the case A reflects ideological aspects such as vision driving for internationalization and better corporate growth opportunities. The case B indicates ideological aspect like survival from economical crises and creating the new media concept. The case C reflects influence and sharing of language, processes and ideology provided by the strategy tool used. Hence, strategy was shaped in all cases by intellectual means. Trust development is supported by an ideological process. Hence, ideological process is a psychological influencing process for building and sustaining trust.

Despite of the fact of intellectual shapers of strategy, all cases indicate strong mental limitations concerning abilities, mind maps, hidden agendas in individual, interpersonal or

dyadic thinking and strategy formation issues. Hence, constructed discursive realities, in each case, included issues not supporting trust development. Mental is a cognitive process of strategic thinking and reasoning for sense-making.

The case A perspectives and hidden agendas were hindering discursive strategy work, even though, participation was high. Abilities and mental limitations did not drive for mutual strategy. The case B shows high participation and drive for new strategy and tremendous change in performance. However, mental abilities and mind maps hindered renewal after good start and power game of the middle management with own interest and agendas was realized. As a result transformation was slowed down. Trust development was based on participation and communication but distrust was supported by poor human capital concerning abilities to communicate on strategic level that management level expects. More explicitly trust is as a skill, way of leading, and power for influencing (Savolainen, 2010). Trust in managerial leadership is seen as intangible, intellectual capital.

Participation does not guarantee trust development if intellectual competence and mental abilities and transparence do not reach required strategic management level. The intellectual base provides language and processes for knowing and intending. The mental base provides opportunity to address results of own strategic thinking and reasoning, agendas and views for strategy work. However, interest, power games and power unbalances may hinder open communication and discourse.

It seems that intellectual aspect is easier to accept than mental. In the intellectual process trust development seems to be more process, doctrine and model driven. In the mental processes trust development seems to be more ability and cognition and psychologically driven where feeling and emotions and interest play key role.
Summing up findings from trust and trust development perspective using, concept of ideology, it can be argued that trust and trust development is an ideological influential process based on issues instead of singular thing or factor. Trust development process can be called thereof issue-based design. Trust develops about certain issue or ideology that is having active influential power. In other words singular things or process phase may not be that strategic in terms of trust development than strategic issues as factors.

Thereof trust can be high or strong enough to support trust leadership in strategic change or transformation in question. The case A indicates internationalization as an ideological issue, the case B indicates survival as an ideological issue and the case C indicates an ideological vision of modernization of management system.

Trust development has been argued to be a process with different stages, or contextual (Lewicki et al., 2996; McAllister et al., 2006), or integrated (Savolainen, 2009). Trust as an issue or ideology can be argued to be like a fire of a vision or good news like a gospel.
Ideology is a driver of motivation towards a desired direction or goal and excellence. Ideology is seen as a mean of influencing (Savolainen, 2008). Hence, if trust is an ideology, then it can be argued that trust is a way of influencing (influential power) boosting to better performance and developing competitive advantages as well.

Strategy work is a psychological influencing process for building and sustaining trust. In constructed reality strategy work is ment to be an emerging process of communication and discourse including sharing and influencing. That is to say that in interactive (discourse, communication, participatory) strategy work trust is shared and is a relational influencing power. Reality is constructed based on intellectual and mental, cognitive processes (visible or invisible realities) forming into ideologies. Intellectual and mental processes have to be realized in order to emerge trust in the context of strategy process.

Thereof the ideological view can be called a psychological influencing process for building and sustaining trust. That has activities, effects, influences (power-games) and consequences. Trust can be argued to be psychological influencing process as ideology.

Finally boundary surfaces (interfaces) of constructed realities are important not only to the birth of innovations but also to trust development in the context of strategy work. Interactive interfaces are even more inevitable for TMTs as theirs influence is critical in terms of development of ideologies.

This paper encourages continue the study with analyses of primary - in early progress towards doctoral dissertation – due to exceptionally interesting phenomenon and its strategic significance.

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F4 – Financial perspectives

F4.1 **Use of financial information in small business management in Poland – Entrepreneur's information needs and their endogenous factors**
Dr. Jacek Jaworski

F4.2 **Identifying market takeoff in high tech industries**
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F4.4 **Financial instruments usage and strategic earnings reporting – The complement hypothesis examination**
Hung-Shu Fan

USE OF FINANCIAL INFORMATION IN SMALL BUSINESS MANAGEMENT IN POLAND - ENTREPRENEUR'S INFORMATION NEEDS AND THEIR ENDOGENOUS FACTORS*

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ABSTRACT

The main problem of small firms is their low "survival". Limited access of small enterprises to reliable and well-prepared information about their condition is mentioned as the cause of that situation. Such information determines the rationality of decisions and the effectiveness in achieving objectives which each company sets ahead. One of the key types of information used in management is financial information. It concerns the resources and financial flows in the enterprise. It is the basis for investment and financing decisions that are the essence of each enterprise.

The main goal of the paper is to present the results of the questionnaire survey and their analysis conducted in mid. 2010 among managers of small enterprises in Poland. The survey was used to recognize the usefulness of financial information in decision-making, to diagnose information needs of entrepreneurs and to identify factors affecting these needs.

Keywords: information needs, small business management, information in decision making

INTRODUCTION

The importance of small companies in the modern economy cannot be underestimated. In 2008 they produced 37.1% of Polish GDP, employed 51,8% of all employees and accounted for 98,95% of active companies in Poland (Wilmańska, 2010). In other European countries the situation is similar.

Nowadays, the main problem of small firms is their low "survival". The limited access of small enterprises to reliable and well-prepared information about their condition is one of the main reasons for this situation. Such information determines the rationality of decisions and achieving objectives which each company sets ahead. In turn, one of the key types of information used in management is financial information. It concerns the resources and financial flows in the enterprise. It is the basis for investment and financing decisions that are the essence of each enterprise. Therefore, from the perspective of further development of small businesses, it is utmost important to recognize the degree of utilization of financial information by entrepreneurs in decision-making, and thus to diagnose their information needs. It was achieved by the questionnaire survey. It should be noted that such survey was conducted in Poland for the first time. The main goal of the paper is to present the results of this research.

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In addition to recognition and evaluation of manager's information needs, I have decided to identify their factors by testing the hypothesis that these needs mainly depend on education of the entrepreneur, the size and nature of a business activity and the life-cycle phase in which the company is. The discussion of the empirical research results was complemented by a brief description of the financial information and their role in management. The description was prepared on the basis of the review of the contemporary professional literature.

FINANCIAL INFORMATION AND ITS ROLE IN CORPORATE MANAGEMENT - LITERATURE REVIEW

Information Determinants of Enterprise Management

In theory of information (Przybyłowicz, 2008, p. 1), it is assumed that information is a primary concept. It means that defining information using simple terms is not possible. Therefore, the explanation of the meaning of information is made with reference to human intuition. Generally, information is defined as (Szymczak, 1993, p. 788): "notification of something, communicating something, message, indication, instruction...". This definition focuses on the utilitarian sense of information. Such an approach to information in economic sciences examines the management theory. It defines information in many ways:

- "information – it is communication, the communication, which eliminates the uncertainty" (Shannon, 1943, p. 17),
- "information is a knowledge transfer to the recipient of information, because its value allows him to reduce uncertainty" (Ackoff, 1969, p. 21),
- and concludes: "information is a kind of resource that can increase our knowledge about ourselves and the world around us" (Kisielnicki, Sroka, 2005, p. 15).

These definitions underlie a valuable and pragmatic theory of information.

In view of the first theory, information is assessed by determining its values for the decision. This theory allows us to maximize the benefits from the information during decision making [Rokicka-Broniatowska, 2002, p. 78]. Treating the information as one of the corporate resources, the most important commodity, whose value is assessed through the prism of usefulness in business processes, is a feature of the pragmatic theory. Such information is called economic information. Management information is a particular type of economic information. It allows us to carry out basic functions of management (planning, organizing, leading and monitoring). In this way, it reduces the uncertainty of particular actions and ensures the correctness of *a priori* decisions [Wrycza, 2010, p. 62].

The information is classified according to various criteria. Table 1 shows the most frequently mentioned classifications and characteristics.

Managers of modern companies try to obtain relevant and well-prepared information. The characteristics of such information are [Wrycza, 2010, p. 64]:

- relevance - the information must be relevant to the problem and help to solve it,

- detail - the information should be detailed enough to resolve a problem (accurate and precise); too many details create excessive costs, but too much vagueness increases the risk of making a mistake,
- completion - the provided information must include, as far as possible all aspects of the analyzed problem,
- reliability - the source of information must be credible and the information itself must be reliable and true,
- timeliness – the information should be provided within a proper time, it should primarily focus on future periods, but without losing connection with the present,
- adequate addressing – the information should be delivered to a proper and competent person who is responsible for solving a problem,
- proper transmission – the information should be provided by the appropriate communication channel (face to face, in public, via e-mail, traditional post, etc.).

Table 1: Classification of Information (Wrycza, 2010, p. 63; Kisielnicki, Sroka, 2005, p. 15).

Criteria	**Classification**	**Characteristic**
Source of the information	• internal, • external,	• the source is an internal system of organization, • the source is the organization environment,
Measurements	• quantitative, • qualitative,	• measurable; numerical description of the problem is possible, • immeasurable; numerical description of the problem is impossible,
Time	• historic, • current, • future,	• about the past (retrospective, *ex post*), • about the present, • about the future (prospective, *ex ante*),
Level of management	• operational, • tactical, • strategic,	• important for short-term decisions, • significant in medium-term decision making, • important for long-term decisions,
Area of management	• marketing, • financial, • R & D, • about workers	• concerning the market on which the organization operates, • related with financial categories, • concerning the undertaken studies and implemented innovation, • concerned with the use of human resources

The information with the above characteristics is an essential element of the decision making process. Its algorithm presented by J. Kumal (1976) includes the information flows intertwined with objects and decision-making entities:

1) decision situation (information about the decision-making situation),
2) decision problem (information necessary for solving a decision-making problem),
3) variants of the decision (information about possible developments in decision-making situation),
4) criteria for decision-making,
5) the decision (the solution to the decision-making problem),
6) the responsibility for a decision and the implementation of a decision,
7) information about the effects of decisions and their control.

Consequently, there are three types of decision-making conditions depending on the degree of knowledge about the problem (Mytlewski, 2010, p. 56):

- decisions undertaken in the conditions of certainty - the manager can correctly predict the results of all activities covered by the decision on the basis of the information,

- decisions undertaken in the conditions of risk – the information allows managers to estimate the probability of all consequences of possible decisions,
- decisions undertaken in the conditions of uncertainty – there are not known potential consequences of taken decisions, or there are no estimates of the probability of their occurring in the future.

In the context of the discussed conditions, the identification of information content, information needs and the implementation the proper information system are very important tasks for the manager. The realization these tasks, leads to more decision-making in certainty, and less decision-making in the conditions of uncertainty.

Types and Domains of Financial Information in the Enterprise

The corporate finance includes all economic phenomena related with the collection and spending funds on business activities of the company (Bień, 2002, p. 14). They also include the analyses and decision-making regarding the choice between the financial sources and their uses available for the company (Brealey, Myers, 1999, p. 31). It means that financial decisions are significant components in corporate management and they require support by relevant information.

The information, whose content concerns financial flows in the enterprise, may be called financial information. Such information carries messages and decisions concerning the formation of all economic phenomena related with the corporate finance. In the classification of financial information, multiple criteria can be used. Taking into account the usefulness of this information in management, the key criteria will be:

- the period for which the decisions are taken,
- the scope of those decisions.

As regards the first criterion, the future of the company is usually divided into two periods where decisions are taken (Brealey, Myers, 1999, p. 45; Bień, 2002, p. 25):

1) short term (up to 1 - 3 years) – operational management,
2) long term (over 3 years) – strategic management.

Taking into account the subject of management, financial decisions (information) can be classified into three areas (Ross, Westerfield, Jordan, 1999, p. 20; Bień, 2002, p. 21-22; Jaworski, 2010, p. 36):

1) capital budgeting – it is based on identifying ways of investing in the company assets;
2) building the financial structure – it is the result of the selection of the available financing sources (own and foreign);
3) working capital management – it means decision-taking determining the levels of current assets (inventories, receivables and cash) and their turnover rate in relation with the current liabilities payment deadlines.

The first two areas primarily relate with long-term decisions; as for the third area, the domain is short term.

In the short term, the company usually seeks to achieve a satisfactory profit which, in effect, it wants to transform into additional, unladed (free) cash flow (Bień, 2002, p. 16; Jaworski,

2010, p. 25). In this respect, in particular, the decisions taken by the company should be aided by information about:

- ability to generate profits (profitability),
- shaping the current and future revenue,
- and incurred and planned costs.

In addition to profit maximization, decisions in the area of working capital management should also include a second important task - the maintenance of liquidity (ability to regulate current liabilities). It is a very important task, because the loss of liquidity is the main cause of bankruptcy of today's companies (Ross, Westerfield, Jordan, 1999, p. 21; Jaworski, 2010, p. 36). Direct information about the current and expected liquidity should also be accompanied by:

- information about the demand for cash in the short term,
- information about the efficiency and effectiveness of management of current assets and liabilities.

In accordance to the widely accepted opinion (Ross, Westerfield, Jordan, 1999, p. 26; Jaworski, 2010, p. 25] the main long-term financial goal is to maximize the company's value. In this context, information about current and projected value of the company appears to be significant information for long-term management. This value derives primarily from the long-term financial performance and the relationship between assets and capitals of the enterprise. Therefore, relevant information in long-term management also concerns:

- profitability of investments,
- shape of the company's financial structure (the company's debt),
- cost of the capital used in assets financing,
- company's financial condition in relation to its competitors and business sector,
- and of course – expected financial results of the planned long-term activities.

EMPIRICAL RESEARCH AND ITS RESULTS

Research Methods

As a practice shows, small enterprises do not often have a system of providing a sufficient quantity and quality of information. Therefore, to optimize the cost of its acquisition, the information needs of managers should be identified carefully. For this purpose I conducted the questionnaire survey among 1008 small enterprises in Poland in mid. 2010.

The surveyed companies were selected according to the proportion resulting from the indicators in the general population in relation to the size of the enterprise, nature of the business activity and geographical distribution. It means that the selected sample can be regarded as representative.

The survey was conducted using CATI method (Computer Assisted Telephone Interview). I asked the entrepreneurs: what financial information they usually expect to receive before taking short-and long-term decisions. In both areas, the respondents had a choice between 7 types of information selected in the previous section of the paper (table 2).

The entrepreneurs chose, in their view the appropriate type of information and had to assess its importance in decision-making using a 1-5 scale. The evaluation could concern a

few types of information with the possibility of the multiple use of the same assessments. The main goal of the used scale was to characterize the subjective view of the entrepreneurs on the importance of information types in decision-making (1 – the least important, 5 – the most important). This numerical weighting allows for using the statistical measures for the assessment of the response's distribution.

Table 2: List of Financial Information Types Used in the Survey.

Short-Term management	**Long-Term management**
Information about: ➢ ability to regulate current liabilities (liquidity), ➢ ability to generate profits (profitability), ➢ efficiency of the activity, ➢ short-term demand for cash, ➢ current and future income, ➢ current and future costs, ➢ other information.	***Information about:*** ➢ level of debt, ➢ cost of capital, ➢ profitability of investments, ➢ current and future value of the company, ➢ company's financial condition in relation to its competitors and business sector, ➢ expected financial results of planned long-term activities, ➢ other information.

In addition to the main subject, there were some questions in the questionnaire which allowed me to extract the endogenous factors forming these needs: the entrepreneur's education, the size and nature of business activity and the life-cycle phase of the company. The structure of the surveyed sample according to the mentioned factors is presented in Table 3.

Table 3: Structure of Surveyed Entrepreneurs.

Partition	**Quantity**	**Percent**	**Partition**	**Quantity**	**Percent**
Size of enterprise			**Nature of business**		
Kept themselves	201	19.94	Services companies	439	43.55
1-9 employees	448	44.44	Commercial companies	302	29.96
10-19 employees	204	20.24	Production companies	147	14.58
20-49 employees	155	15.38	Combined business	120	11.90
Company's age			**Life-cycle phase***		
Up to 1 year	314	31.15	Entry phase	58	5.75
1 – 3 years	255	25.30	Dynamic growth phase	145	14.38
3 – 6 years	189	18.75	Stability phase	253	25.10
Over 6 years	250	24.80	End-stage phase	422	41.87
Entrepreneur's education					
Basic or vocational	30	2.98	Higher humanistic	91	9.03
Secondary vocational	85	8.43	Higher technical	333	33.04
Secondary general	229	22.72	Higher economic	240	23.81

*- life-cycle phase was based on the answers to questions about changes in income, profits and investment needs in the enterprise.

To examine the relationship between the diagnosed information needs and the above factors, I have used the chi-square compatibility test (Balicki, Makać, 2000, pp. 227-231). The mathematical aspect of the Chi-square test is reduced to calculate the statistics:

$$\chi^2 = \sum_{i=1}^{k}\sum_{j=1}^{l}\frac{\left(n_{ij} - \hat{n}_{ij}\right)^2}{\hat{n}_{ij}} = \sum_{i=1}^{k}\sum_{j=1}^{l}\frac{n_{ij}^2}{\hat{n}_{ij}} - n \quad ,$$

where:

l, k – kinds of first and second variables (entrepreneur's score for each kind of information and assumed factor),

n_{ij} - empirical numbers of the simultaneous co-occurrence of pairs of variables *i* and *j*,

$\hat{n}_{ij} = \frac{n_i \times n_j}{n}$ - expected numbers of the simultaneous co-occurrence pairs of variables *i* and *j*,

n - the number of all respondents' answers.

The calculated statistics is compared with the theoretical value of chi-square distribution (read out from the statistical tables for specific values *k* and *l* and the significance level). If χ^2 is less or equal to read value, then there is no reason to reject the hypothesis about the independence of variables. Otherwise, there are reasons for accepting the alternative hypothesis saying that the variables are dependent.

To determine the strength of the correlation between the examined factors and entrepreneurs' evaluation of information needs, I have used T-Czuprow and C-Pearson contingency coefficients (more: Makać, Urbanek-Krzysztofiak, 2001, pp. 152-162). Mathematical definitions of these coefficients are presented in Table 4.

Table 4: T-Czuprow and C-Pearson Contingency Coefficients (Makać, Urbanek-Krzysztofiak, 2001, p. 155)

T-Czuprow	**C-Pearson**
$T = \sqrt{\frac{\chi^2}{n \times \sqrt{(k-1)\times(l-1)}}}$	$C = \sqrt{\frac{\chi^2}{\chi^2 + n}}$

The values of both coefficients are in the range (0-1). The correlation between the examined variables is stronger when the coefficients' values are higher. For the purpose of this research it is assumed that (Barańska, 1999):

- the correlation is weak when both indicators are less than 0.30,
- the correlation is moderately strong when the indicators are in the range (0.30 – 0.60),
- the correlation is strong when the values of coefficients are higher than 0.60.

The significance level for chi-square distribution is set on 0.1.

For the overall evaluation of the survey results (the entrepreneur's responses), I used the structural analysis based on the central tendency measures (the arithmetic average, median and mode). These methods have also been applied in the description of the respondent's answer distribution according to the statistically significant diagnosed factors. The analysis results are presented graphically, which supplements the written description.

Research Results

Diagram 1 presents the global results of entrepreneurs' answers about information needs in short-term decision making.

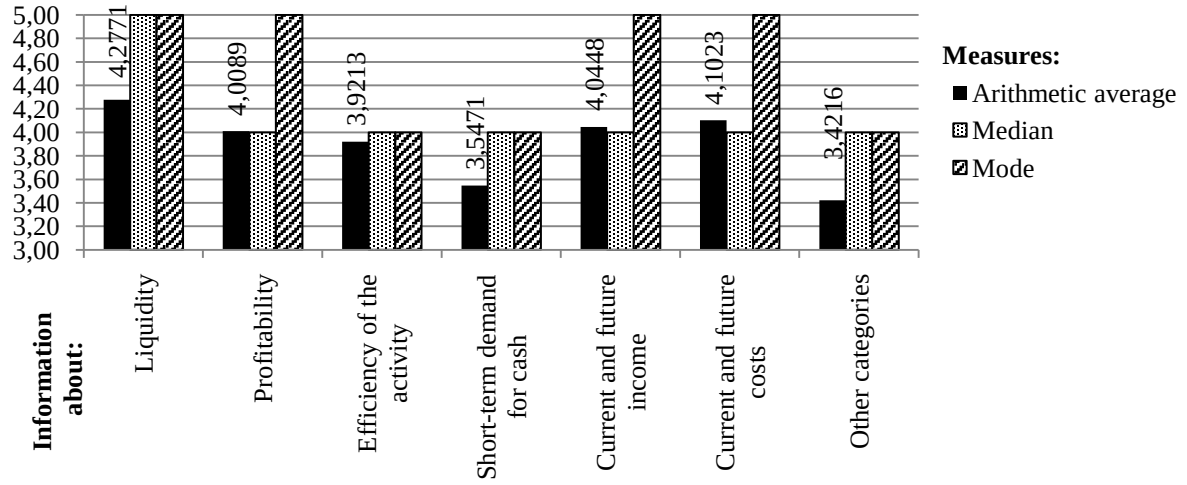

Diagram 1: Assessment of Information Types Expected in Short-Term Decision Making.

In all managers' opinion, the most important information in short-term management is about the ability of the company to regulate current liabilities (liquidity). The importance of that information was most frequently evaluated by entrepreneurs to 5.0 (mode). The same level is noted for median. The arithmetic average is 4.2771. The information about current and future costs obtained not much lower average score (4.1023). However, in this case, half of the ratings were less than or equal to 4.0 (median). Entrepreneurs, being equally important, found information about current and future income (4.0448). The ratio of incomes and costs or profitability of the enterprise is also significant (4.0089). Information about efficiency is less important in short-term decision making (3.9213). This last type of information was the most often assessed at 4.0 (mode). The information about future demand for cash is the least important for entrepreneurs in short-term management (3.5471). The same situation concerns other information (3.4216).

Summing up the results for short-term management, very high average scores for most of the assumed types of information should be noted (above 4.0). It means that small business managers attach great importance to short-term decisions, and in turn it causes high demand for all information about the achievement of short-term corporate goals.

Ratings for the long-term management are a bit lower (see Diagram 2). The information about the level of the company's debt and about profitability of investments has usually obtained the highest scores (mode: 5.0). The average assessment is 3.9740 and 3.9095 respectively.

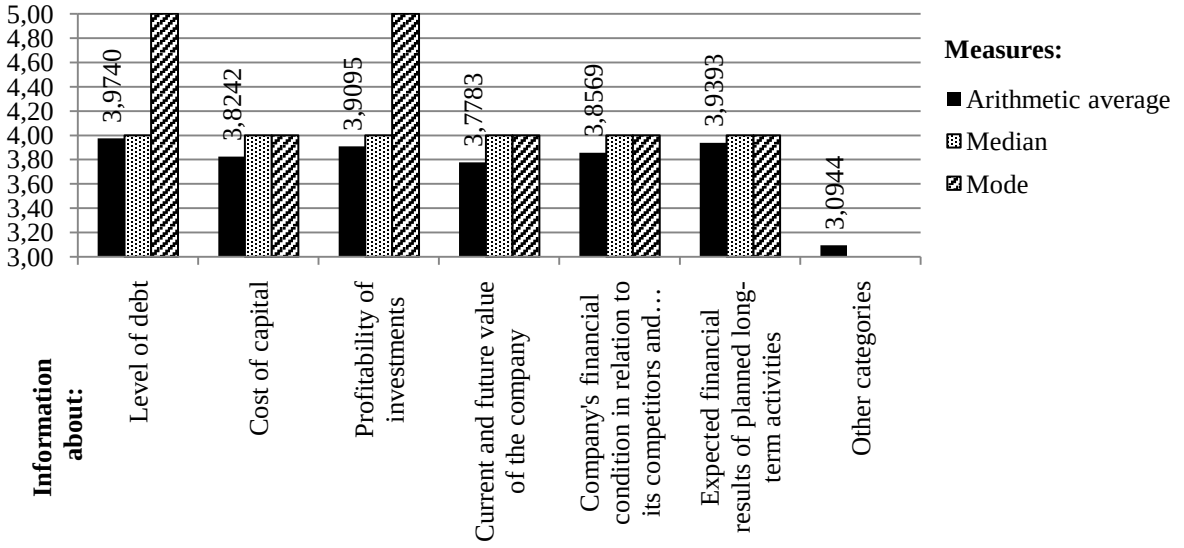

Diagram 2: Assessment of Information Types Expected in Long-term Decision Making.

The information about financial effects of the planned long-term activities received very high average scores (3.9393). Median and mode 4.0 mean that entrepreneurs assessed this area of information as very stable and balanced. The information about the company's financial condition (3.8569) and the cost of capital (3.8242) were rated similarly, but slightly lower. Some entrepreneurs pointed also other categories of financial information, but their importance rated quite low (3.0944; mode and median 3.0).

Table 5 presents calculations of Chi-square statistics and contingency coefficients for selected factors in short-term management.

The presented calculations show that the entrepreneurs' information needs depend mainly on the size of the enterprise. To some extent they are affected by managers' education. The weakest dependence can be observed for a life-cycle phase in which company is. For the rest selected factors (age of the company and nature of the business), the dependence does not exist.

Table 5: Influence of Endogenous Factors on Entrepreneur's Information Needs in Short-Term Management.

Information about	**Liquidity**	**Profi-tability**	**Efficiency**	**Demand for cash**	**Income**	**Cost**	**Other**
Factor	**Size of enterprise**					**Theoretical** χ^2 = 18,55	
Empir. χ^2	32.86	23.59	36.27	17.44	16.84	18.72	26.06
Dependence	Exist	Exist	Exist	Not exist	Not exist	Exist	Exist
T-Czuprow	0.0971	0.0822	0,1021	-	-	0.0733	0.1391
C-Pearson	0.1778	0.1513	0,1867	-	-	0.1351	0.2506
Correlation	Weak	Weak	Weak	-	-	Weak	Weak
Factor	**Entrepreneur's education**					**Theoretical** χ^2 = 28.41	
Empir. χ^2	26.48	32.14	35.16	49.84	20.37	22.99	22.14
Dependence	Not exist	Exist	Exist	Exist	Not exist	Not exist	Not exist
T-Czuprow	-	0.0846	0.0886	0.1057	-	-	-
C-Pearson	-	0.1760	0.1841	0.2182	-	-	-
Correlation	-	Weak	Weak	Weak	-	-	-
Factor	**Life-cycle phase**					**Theoretical** χ^2 = 23.54	
Empir. χ^2	16.96	17.04	23.28	29,91	13.32	24.63	19.42
Dependence	Not exist	Not exist	Not exist	Exist	Not exist	Exist	Not exist
T-Czuprow	-	-	-	0.0866	-	0.0782	-
C-Pearson	-	-	-	0.1706	-	0.1545	-
Correlation	-	-	-	Weak	-	Weak	-
Factor	**Nature of business**					**Theoretical** χ^2 = 18.55	
Empir. χ^2	7.34	15.38	6.17	13.20	8.91	15.20	12,28
Dependence	Not exist	Not exist	Not exist	Not exist	Not exist	Not exist	Not exist
Factor	**Company's age**					**Theoretical** χ^2 = 18.55	
Empir. χ^2	7.78	9.74	6.93	8.21	10.01	10.53	7.64
Dependence	Not exist	Not exist	Not exist	Not exist	Not exist	Not exist	Not exist

In the case of the company size, it influences the entrepreneurs' responses in the five areas of financial information (liquidity, profitability, efficiency, costs and other financial categories). Entrepreneurs' education shapes their information needs in three areas - information about profitability, efficiency and demand for cash. However, the life-cycle phase only in two categories – information about the demand for cash and cost levels. In all cases of dependence, the correlation is weak: T-Czuprow and C-Pearson coefficients are less than 0.3. Diagrams 3 – 5 present distribution of entrepreneurs' answers for diagnosed dependencies.

The research clearly shows that the larger enterprise the more attention is paid to all types of information concerning short-term management. Differences in the assessment range are from 4% in the case of information about the demand for cash to 10% in the case of information about liquidity. Larger companies assess (3.6471 to 3.2571) the importance other information as higher. This indicates that the size of the company determines increased demand for information. The distribution of received scores for each type of information is the same as for the whole population (see Diagram 1).

The distribution of assessments, depending on entrepreneurs' education is considerably more diverse (Diagram 4). The highest rating for all dependent information is made by entrepreneurs with higher economic education, while the lowest by managers with higher technical education. Relatively high ratings are issued by entrepreneurs with basic and vocational education. From the three presented types of information, the most important is information about profitability (3.6296 – 4.2042) and the least important is about the demand for cash (3.2319 – 3.8033).

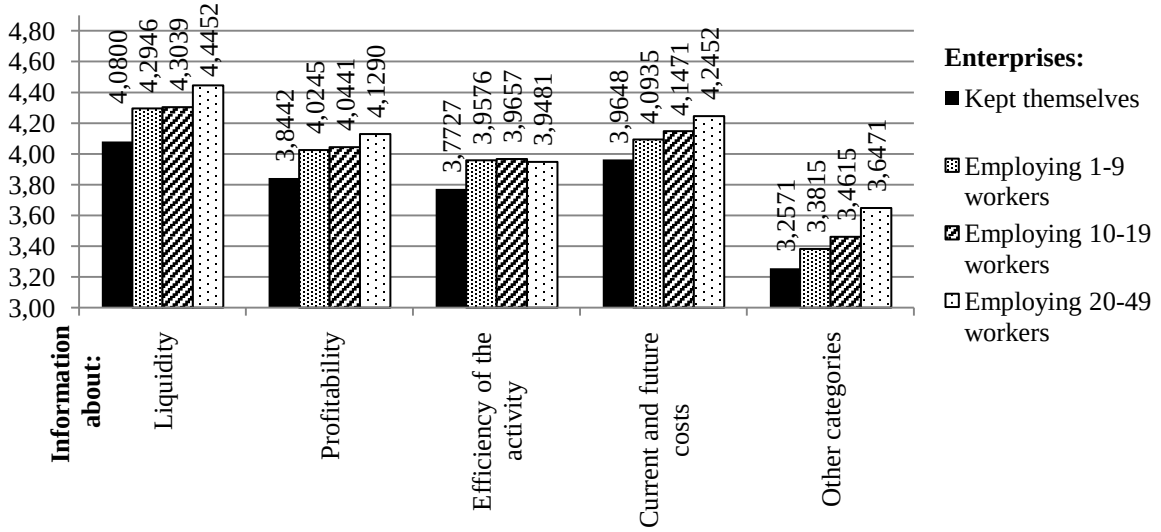

Diagram 3: Distribution of Assessment of Information in Short-term Management According to Size of Enterprise.

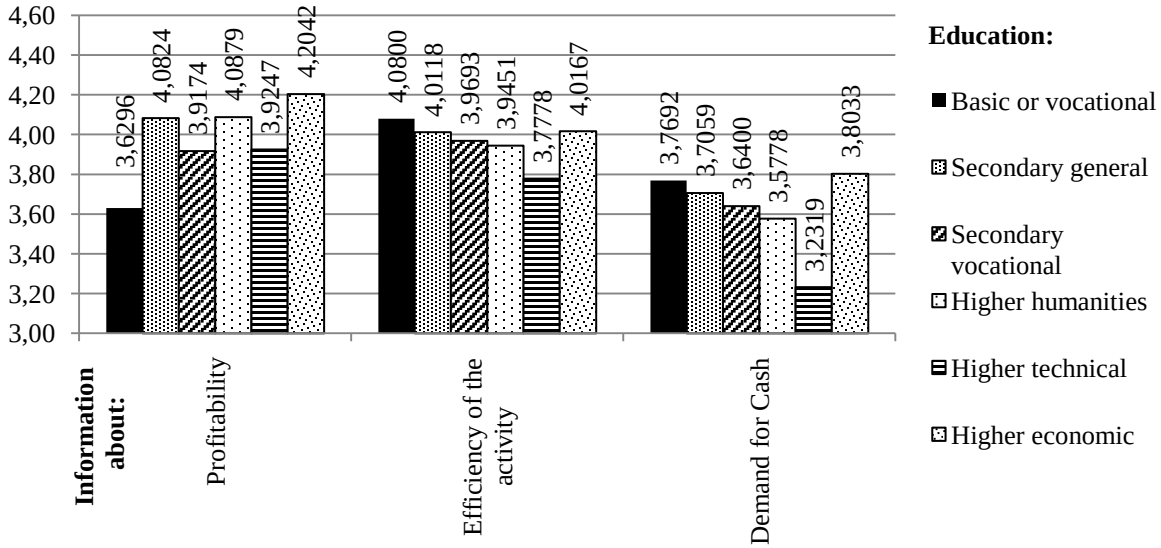

Diagram 4: Distribution of Assessment of Information in Short-term Management According to Manager's Education.

The life-cycle phase affects the information needs only in two areas (Diagram 5). For all companies the information about the costs level is more important. This is particularly true for companies in the entry and growth phases. In the stability and end-stage phases, entrepreneurs are especially interested in the demand for cash.

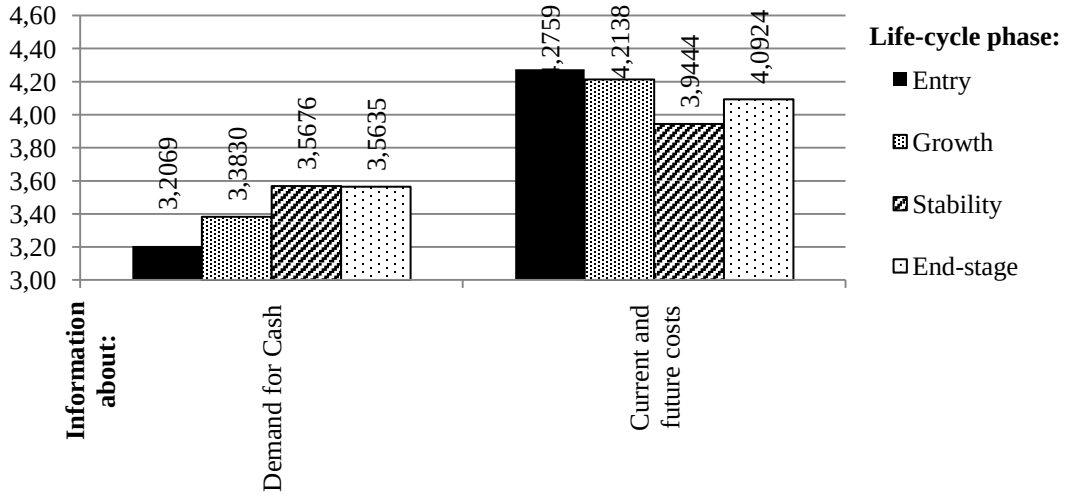

Diagram 5: Distribution of Assessment of Information in Short-term Management According to Life-cycle Phase.

Table 6 presents calculations of Chi-square statistics and contingency coefficients for selected factors in long-term management.

Entrepreneurs' information needs in long-term management, similarly to the short-term management depend on the size of the enterprise, managers' education and the life-cycle phase of the company. In the first case, it concerns six types of information (level of debt, cost of capital, profitability of investments, value of the company, expected results of long-term activities and other categories). In the second case, the dependences are diagnosed in five types of information (level of debt, cost of capital, value of the company, financial condition and expected results of long-term activities). The last case concerns only two areas – value of the company and expected results of long-term activities. In addition, I have diagnosed the dependence of information needs on the nature of business. It concerns the information about the level of debt and about financial condition in relation to the company's competitors and business sector. The distribution of entrepreneurs' answers is presented on Diagram 6 to 9.

Assessment of the information in the long-term management confirms the trand that the larger size of the enterprise determines the increased information needs of its manager (scores of the largest enterprises are the highest – Diagram 6). Differences in ratings range from 4.7% (information about profitability of investments) to 8.7% (information about the level of debt). The information about the level of debt is the most important for the largest enterprises. For the smallest ones – about profitability of investments. The rest of the assessments did not differ from the average (Diagram 2).

For entrepreneurs with higher education, information about the expected results of long-term activities is the most important. The information about financial condition in relation

to competitors and the business sector is the most significant for managers with lower education (see Diagram 7). Assessments of other types of information are more diversified. However, the lower demand for information is typical of entrepreneurs with vocational (technical) education, regardless of the level.

Table 6: Influence of Endogenous Factors on Entrepreneur's Information Needs in Long-Term Management.

Information about	**Level of debt**	**Cost of capital**	**Prof. of invest.**	**Value of company**	**Finan. Cond.**	**Expected results**	**Other**
Factor	**Size of enterprise**					**Theoretical** χ^2 = 18.55	
Empir. χ^2	30.62	27.39	26.33	22.75	16.15	22.07	22.55
Dependence	Exist	Exist	Exist	Exist	Not exist	Exist	Exist
T-Czuprow	0.0940	0.0886	0.0869	0.0808	-	0.0796	0.1386
C-Pearson	0.1723	0.1627	0.1597	0.1487	-	0.1466	0.2497
Correlation	Weak	Weak	Weak	Weak	-	Weak	Weak
Factor	**Entrepreneur's education**					**Theoretical** χ^2 = 28.41	
Empir. χ^2	41.83	52.24	18.16	46.42	37.90	49.97	24.84
Dependence	Exist	Exist	Not exist	Exist	Exist	Exist	Not exist
T-Czuprow	0.968	0.1078	-	0.1017	0.0919	0.1055	-
C-Pearson	0.2005	0.2223	-	0.2102	0.1907	0.2178	-
Correlation	Weak	Weak	-	Weak	Weak	Weak	-
Factor	**Life-cycle phase**					**Theoretical** χ^2 = 23.54	
Empir. χ^2	14.03	21.35	23.46	31.70	21.22	26,49	13.02
Dependence	Not exist	Not exist	Not exist	Exist	Not exist	Exist	Not exist
T-Czuprow	-	-	-	0.0888	-	0.0812	-
C-Pearson	-	-	-	0.1748	-	0.1603	-
Correlation	-	-	-	Weak	-	Weak	-
Factor	**Nature of business**					**Theoretical** χ^2 = 18.55	
Empir. χ^2	26.90	9.18	10.32	15.48	20.50	9.81	9.97
Dependence	Exist	Not exist	Not exist	Not exist	Exist	Not exist	Not exist
T-Czuprow	0.0881	-	-	-	0.0767	-	-
C-Pearson	0.1618	-	-	-	0.1413	-	-
Correlation	Weak	-	-	-	Weak	-	-
Factor	**Company's age**					**Theoretical** χ^2 = 18.55	
Empir. χ^2	11.57	13.75	16.43	9.17	11.61	8.80	5.57
Dependence	Not exist	Not exist	Not exist	Not exist	Not exist	Not exist	Not exist

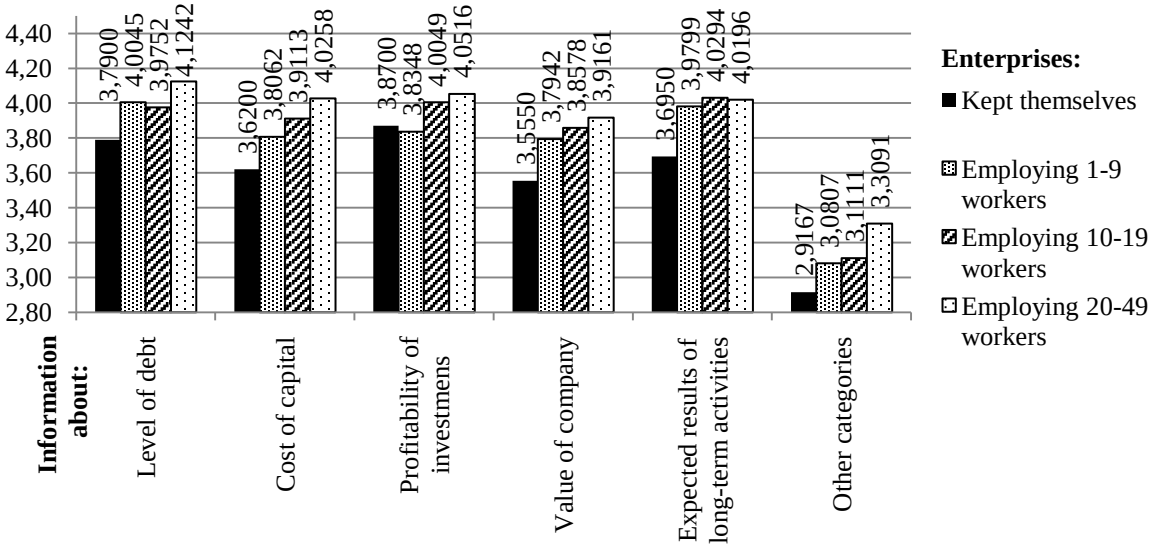

Diagram 6: Distribution of Entrepreneurs' Assessment of Information in Long-Term Management According to Size of Enterprise.

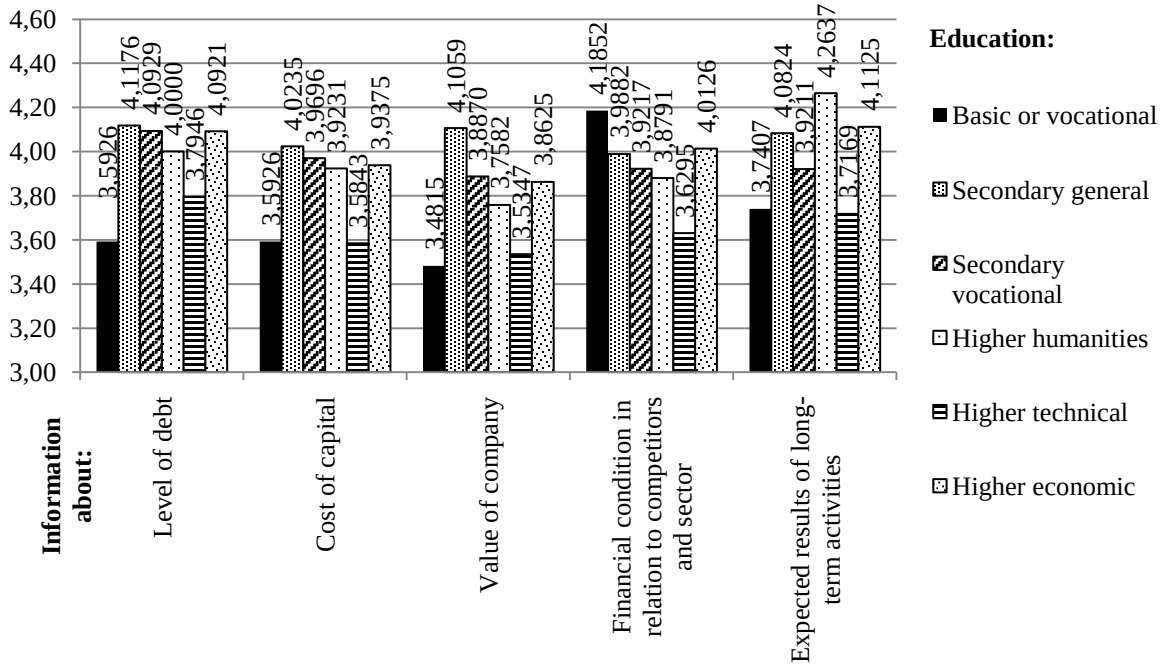

Diagram 7: Distribution of Assessment of Information in Long-Term Management According to Entrepreneur's Education.

Diagram 8 shows that the importance of information about the company's value increases relatively to the phase of the life cycle. As regards the information about the expected results of long-term activities, the situation is reversed. The demand for both kinds of information is very similar for the companies in growth and stability phases of the life-cycle.

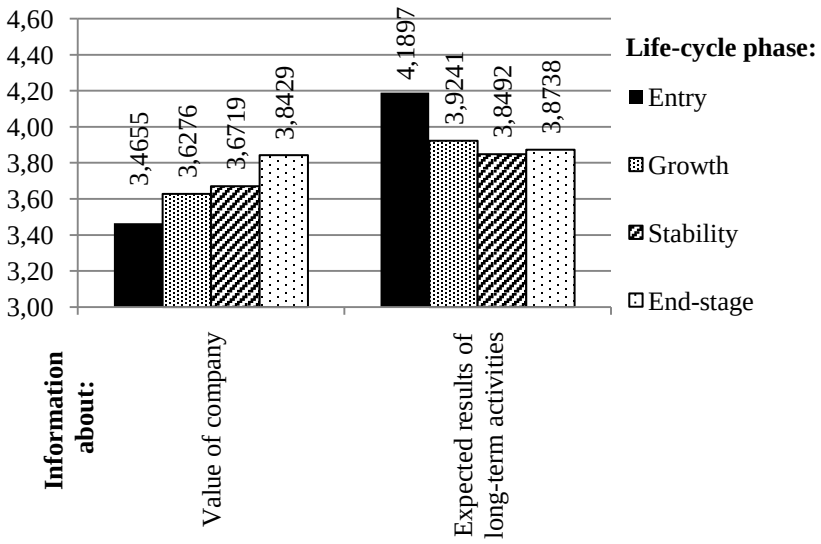

Diagram 8: Distribution of Assessment of Information in Long-Term Management According to Life-cycle Phase.

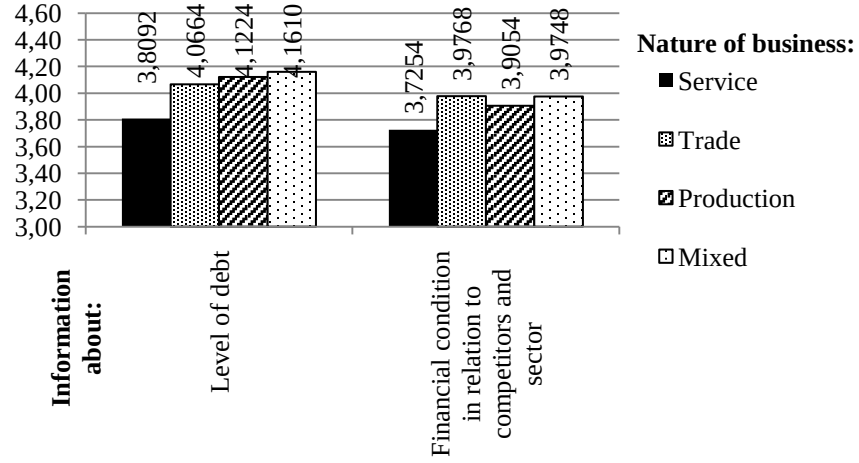

Diagram 9: Distribution of Entrepreneurs' Assessment of Information in Long-Term Management According to Nature of Business.

The research results (Diagram 9) show that the information about the level of debt (4.1610) and about financial condition in relation to competitors and business sector (3.9748) is mostly needed by companies running mixed types of business activities (ca. 4.01 and 3.95). Not much lower level of information needs is reported by production and trading companies**.** However, this information is evidently less important for service companies (3.8092 and 3.7254 respectively).

CONCLUSIONS

Research results are the important characteristics of the small enterprise sector in Poland. They describe the use of various types of financial information in decision making, and

thereby they determine the information needs of entrepreneurs. They allow us to assess the role of financial information in managing a small company, and its owner's managerial competence.

Taking into account general results, entrepreneurs have assessed highly the usefulness of financial information in the company management. The scores for the short-term management exceed 4.0 on the five-point scale. As regards the long-term management, they do not much diverge from that level. It means that managers of small companies often use financial information during decision making and the demand for this information type is significant among them.

In short-term management, information about liquidity (ability to pay current liabilities) is the most important aspect for managers. It shows that for small companies, the maintenance of liquidity is a key short-time problem. In this area, the information about current and future costs is the second on the list of entrepreneurs' information priorities. It follows that the costs are an important and sensitive subject of management in small enterprises. Entrepreneurs have also assessed information about revenues and about the profitability of the company as relatively high. It means that in the short term, in addition to maintenance liquidity, managers try to maximize profit.

The information about the level of debt and about the expected financial result of long-term activities is the most significant in strategic management. Indebtedness and its growth become the primary determinant of long-term policy of a small enterprise. Managers shape its level on the basis of the expected results of taken decisions. In this managerial area, entrepreneurs rated the usefulness of information about cost of capital quite low. In their opinion, the information about the financial condition in relation to competitors and business sector is more significant.

The assumed hypothesis about the relationship between information needs and selected factors (see Table 3) was only partially positively verified. In short-term management these needs depend on the size of the enterprise, entrepreneur's education and the life-cycle phase in which the company is. In addition to those aspects, the dependence on the nature of business is diagnosed for long-term management. In all cases of dependence the strength of correlation is weak. Information needs do not depend on the company's age.

There is a noticeable trend that in larger enterprises their managers assess the usefulness of each types of financial information as higher. This usefulness is evaluated as high by managers with higher economic and humanistic education. Financial information seems to be underestimated by managers with vocational education regardless of its degree. Only selected types of information needs depend on the life-cycle phase and on the nature of business.

Undoubtedly, a very important aspect of management is both the quantity and quality of information used by managers. They expect relevant, significant, full and reliable information. In this context, it can determine the assumption that optimal information system for small enterprises is vital. It will be the aim for my further research.

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IDENTIFYING MARKET TAKEOFF IN HIGH TECH INDUSTRIES

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ABSTRACT

This research we collect US data from both the personal computer (PC) and portable digital music player (commonly referred as MP3 players) industries and used derivative approximation by finite differences method to identify market takeoff. In addition, we examined the relationship between market takeoff and product innovations in the PC and MP3 markets. The derivative approximation by finite differences method eatables researchers to identify the market takeoff at a timely fashion which is an important advantage over the traditional statistical methods which can only perform the task in a retrofitting manner.

Keywords: Market takeoff, Method, PC industry, MP3 industry

INTRODUCTION

Although entry timing often depends on a firm's resources and capabilities (Kerin, Varadarajan, 1992;Lambkin, 1988;Lieberman and Montgomery, 1988;Lieberman and Montgomery, 1998), firms are often confused about which stage of the product life cycle an industry is in and whether it is too early or too late to enter.

The transition between the early commercialization and growth stages has been defined as market takeoff (Golder and Tellis, 1997). On the other hand, Agarwal and Bayus (2002) described market takeoff as "the first large increase in sales," or "the hockey-stick pattern of sales growth also seems to be popular among industry pundits." They used discriminant analysis to determine the timing of takeoff. Similar statistical methods have also been used by other scholars in distinguishing different stages of innovations (Agarwal and Gort, 1996;Gort and Klepper, 1982).

Recognition of market takeoff (the period in which the entire product category has reached the growth stage) is important given the perceived advantage of entering a market just before or at the growth stage (Lilien and Yoon, 1990;Shankar, Carpenter, 1999). The stream of literature describing the dual market development of the early stage innovations (Moore, 2002;Muller and Yogev, 2006) also pointed out the importance of market take off from the aspect of characteristics of customers.

Factors such as economic, and cultural factors (Tellis, Stremersh, 2003), firm promotional activities and timing (Delre, Jager, 2007), social network characteristics (Delre, Jager, 2010;Hohnisch, Pittnauer, 2008) and price drop (Hohnisch, Pittnauer, 2008) can impact the timing of takeoff.

Product innovation may also trigger the market takeoff. A product innovation can provide relative advantages that can increase the adoption rate (Rogers, 2003;Tornatzky and Klein, 1982).

Because this period of takeoff is so significant, it would be helpful for firms to understand the factors that trigger market takeoff. A better understanding of what triggers takeoff and how to recognize it would aid managers in becoming more proactive and effective in their product development efforts and in understanding how timing of product introduction may affect their success (Foster, Golder, 2004;Tellis, 2008).

Employing statistical methods to identiy market takeoff is rigorous but it relies on 20/20 hindsight. One needs to have many data points to determine the market takeoff time. An industry participant during the early stage of an innovation might face difficulties in identifying market takeoff using their method.

Addressing this issue, Golder and Tellis (1997) provided an alternative method to identify market takeoff. They developed a threshold for takeoff defining takeoff as the first year in which an individual category's growth rate, relative to base sales, crosses this threshold. According to the authors, this method identifies 90% of the takeoffs correctly. Further, visual verification helps to ensure the correct identification of takeoff. Their method used a minimum of 50,000 unit sales as a threshold because they found that a relatively large percentage increase could occur without signaling real takeoff. Their method has the advantage in identifying takeoffs in real-time even during the early stages of an innovation. However, is there other method we can use to identify market takeoff in a proactive manner? The market takeoff, it is a *"sudden"* increase in sales. It is essentially a *"big acceleration"* in market sales. The industry sales of the PC innovation was increasing every year. Can we identify the *"big acceleration"* in the PC industry mathematically instead of statistically? We are proposing to use the derivative approximation of finite differences (Eberly, 2001) as an alternative method for the takeoff identification. To achieve this goal, we collected the US PC and MP3 player industry data to examine the possibility of using derivative approximation of finite differences as a market takeoff identification method.

DATA

US Personal Computer Data

In searching for a consistent source for market information for US Personal Computer (PC) industry, I utilized the annual publication of Datamation, the "Datamation 50 and the Datamation 100." Datamation magazine was the key professional magazine for "data processing" industry during the time frame of the study. It was widely subscribed by information technology professionals. I used the following sections of Datamation to construct the quantitative aspect of the industry.

1. The Datamation 50 (1979) conducted by Datamation magazine, is an annual systematic revenue summary of the top 50 Data Processing firms including computer hardware, software, peripherals, and etc.

2. Datamation 100 (1980-1989).

The Datamation 100 is similar to Datamation 50 but includes top 100 firms. (timeframe) Datamation data helped in estimating annual sales for the PC industry which were hard to get from other sources. It was used by Chandler (2001) for his history of the electronics industry (citation). I obtained market share data of the companies through various secondary sources which will be discussed in detail in following sections.

In calculating firm market share I used the following:

Virhe.

I used this relationship to calculate "annual industry sales" by multiplying "annual company sales" (from Datamation) and "company market share (from other sources and books mentioned above). This is a reasonable method for estimating industry sales as it is difficult to get access to this data for the early stage of the industry in any other way. Datamation's data helped to determine the progression of personal computer industry sales over time.

US Portable Digital Music Players Data

Due to the lack of well-organized texts, I performed two broad-term keyword searches on ABInform Database to promote an understanding of technology advances and market size data. The two keywords were 1) MP3, and 2) digital music. The market sales data is thus assembled. The publications on which I performed keyword search can be categorized as 4 types:

1. Business Magazines: 1) Business Week, and 2) Fortune
2. Newspapers: 1) New York Times, and 2) Wall Street Journal
3. Two Popular Technology Magazines: 1) PC Magazine and 2) PC world
4. One Popular Music Magazine: Rolling Stone Magazine

ANALYSIS

Before we presenting our analysis details, we must clarify what is the *"big acceleration"* in sales means. An analogy to concepts in physics is helpful. The annual sales number is actually the *"speed of sales"* because the annual sales of an innovation represents its sales per year (sales/year). Therefore, it is the *"speed of sales"* if we think of the annual industry sales as the displacement of an object. Following this analogy, the annual increase in sales is the "acceleration of sales". This analogy helps in the identification of the *"big acceleration"* of sales. Following this line of thinking, the *"big acceleration"* of sales is actually *"the maximum change"* on the acceleration of sales.

However, mathematically how can we identify *"the maximum acceleration of sales"*? The concept of *derivative approximation of finite differences (Eberly, 2001)* is helpful.

The detail analysis and rationales are presented as follow:

Derivative Approximation of Finite Differences

$S(t)$ is the unit sales of an innovation; where *t* represents time;
The maximum change in the acceleration of sales is the maximum of $S''(t)$; that is the maximum rate of change in the speed of sales. To calculate the $S''(t)$, we must fist understand the calculation of $S'(t)$ under the notion of derivative approximation of finite differences, the derivate of $S'(t)$ can be calculated by forward, backward, and centered difference approximations. Similarly, $S''(t)$ also can be found.
To approximate the derivatives of a univariate function $f(k)$ by finite difference, given a small value of *h*, where *h*>0, the $f'(k)$and $f''(k)$ can be calculated as follow:

Forward difference approximation

$$f'(k)=\frac{f(k+h)-f(k)}{h}$$

Where $h=1$

$$f'(k)=f(k+1)-f(k) \tag{1}$$
$$f''(k)=\frac{\Delta f(k+1)-\Delta f(k)}{1}$$
$$f''(k)=\left[f(k+2)-f(k+1)\right]-\left[f(k+1)-f(k)\right]=f(k+2)-2f(k+1)+f(k) \tag{2}$$

Backward difference approximation

$$f'(k)=\frac{f(k)-f(k-h)}{h}$$

Where $h=1$

$$f'(k)=f(k)-f(k-1) \tag{3}$$
$$f''(k)=\frac{\Delta f(k)-\Delta f(k-1)}{1}$$
$$f''(k)=\left[f(k)-f(k-1)\right]-\left[f(k-1)-f(k-2)\right]=f(k)-2f(k-1)+f(k-2) \tag{4}$$

Centered difference approximation

$$f'(k)=\frac{f(k+h)-f(k-h)}{2h}$$

Where $h=1$

$$f'(k)=\frac{f(k+1)-f(k-1)}{2} \tag{5}$$

$$f''(k)=\frac{\left[\Delta f(k+1)-\Delta f(k-1)\right]}{2}=\frac{\left[f(k+2)-f(k)\right]/2-\left[f(k)-f(k-2)\right]/2}{2}$$

$$f''(k)=\frac{f(k+2)-2f(k)+f(k-2)}{4} \quad (6)$$

To identify the market takeoff of the PC innovation we apply the equations 1 to 6. Where $S(t)$ is the unit sales of an innovation; *t* represents year; *h*=1 (year)
Forward difference approximation

$$S'(t)=S(t+1)-S(t)$$
$$S''(t)=S(t+2)-2S(t+1)+S(t) \quad (7)$$

Backward difference approximation

$$S'(t)=S(t)-S(t-1)$$
$$S''(t)=S(t)-2S(t-1)+S(t-2) \quad (8)$$

Centered difference approximation

$$S'(t)=\frac{S(t+1)-S(t-1)}{2}$$
$$S''(t)=\frac{S(t+2)-2S(t)+S(t-2)}{4} \quad (9)$$

For the purposes of this analysis, market takeoff is defined as the year the maximum increase in sales rate. This point can be estimated from the discrete sales data using the centered difference approximation

$$S'(t)=\frac{S(t+1)-S(t-1)}{2}$$
$$S''(t)=\frac{S(t+2)-2S(t)+S(t-2)}{4}$$

where S(t) is the unit sales in year t.

Takeoff Identification for PC and MP3 Markets

To identify the time of takeoff, given the method's different approaches, we must discuss the advantages of approaches. By plotting the industry sales and maximum peak of three approximation approaches for the PC (Figure 1) and MP3 innovations (Figure 2), we can see that the market takeoff of the PC innovation is identified to be in 1980, 1981, and 1982 respectively by the forward, centered and backward approximations. The year of takeoff for MP3 players were in 2003, 2003 and 2005 respectively.

The Determination of the Proposed Approach—Backward Difference Approximation

However, which of the 3 approximation approaches is correct? We believe that the backward difference approximation because its first order and second order derivatives are generated by the comparison of current and the previous periods. Therefore, the output is more concurrent which is the major purpose of this study—proactive takeoff identification.

Figure 1: PC Industry Unit Sales Evolution and Takeoff Identification.

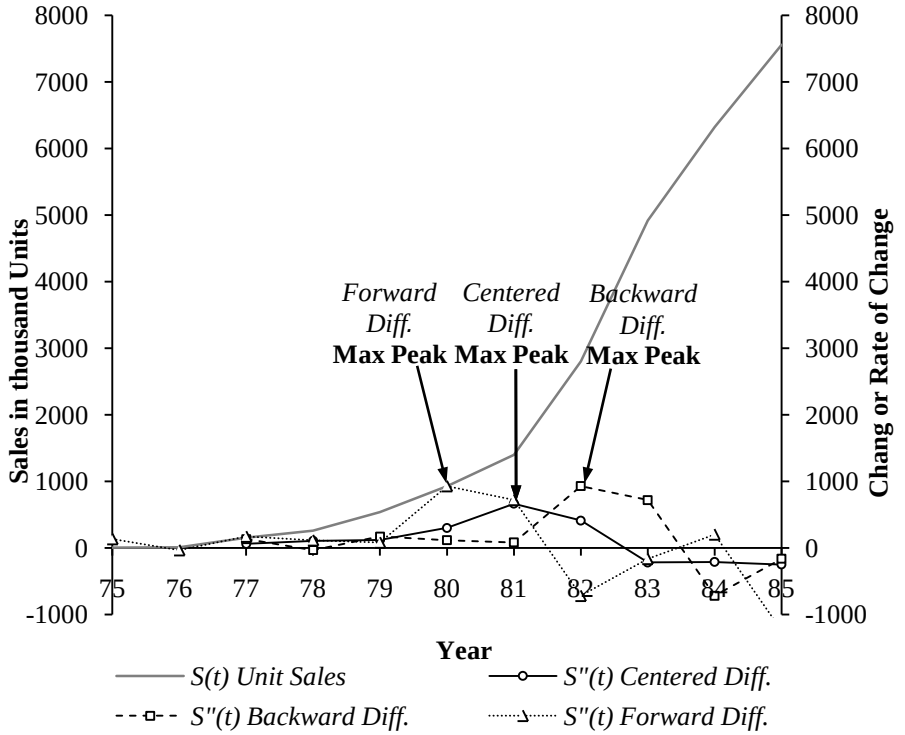


Figure 2: US MP3 Player Sales Evolution and Takeoff Identification.

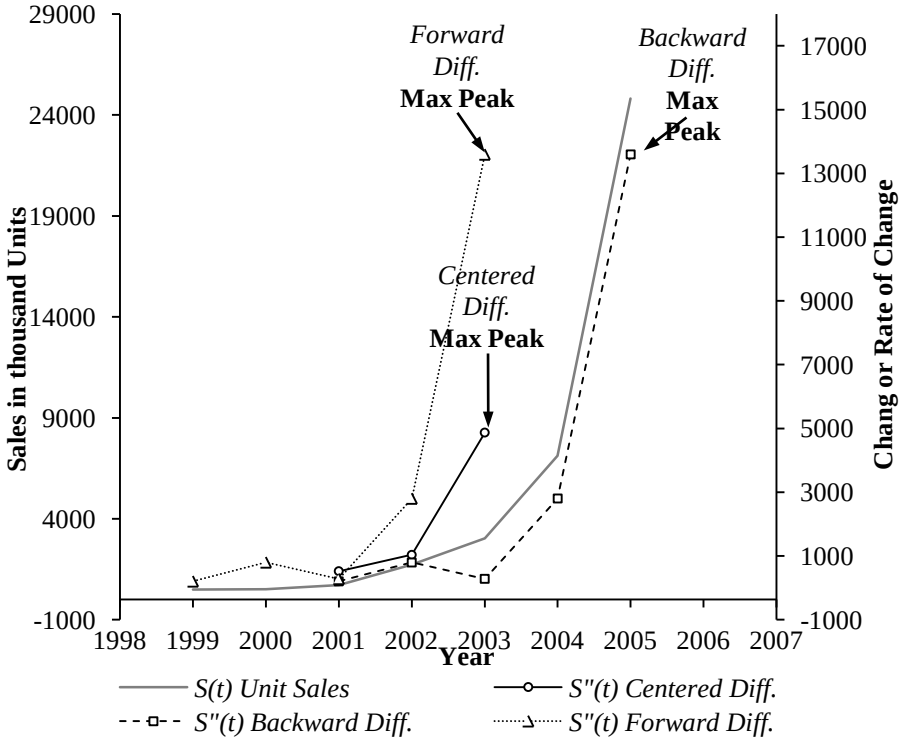


Figure 3: Multiple Takeoffs of the U.S. PC Industry under the Backward Difference Approximation.

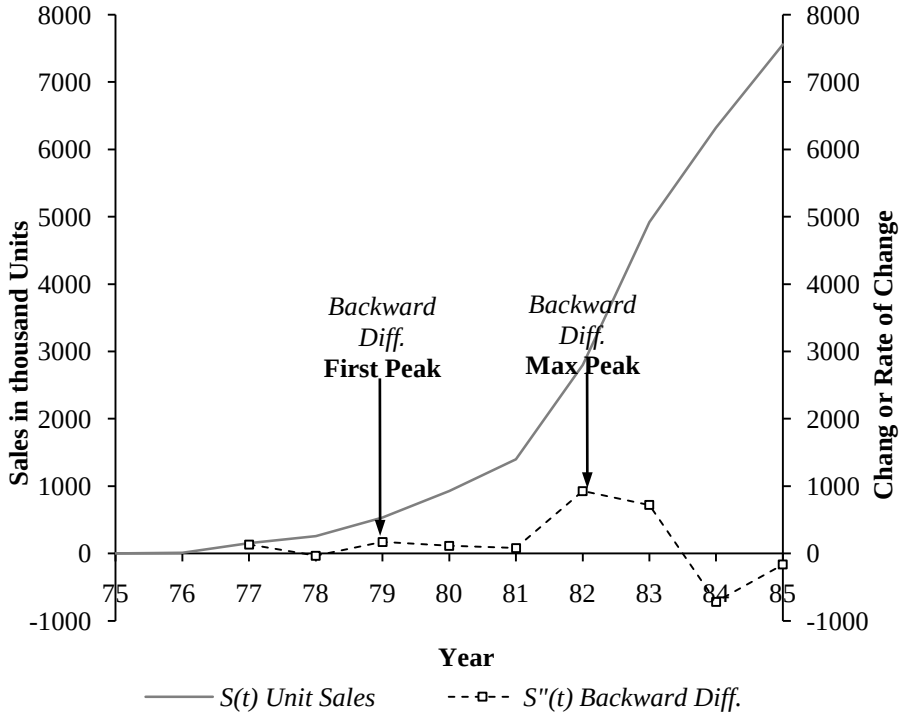
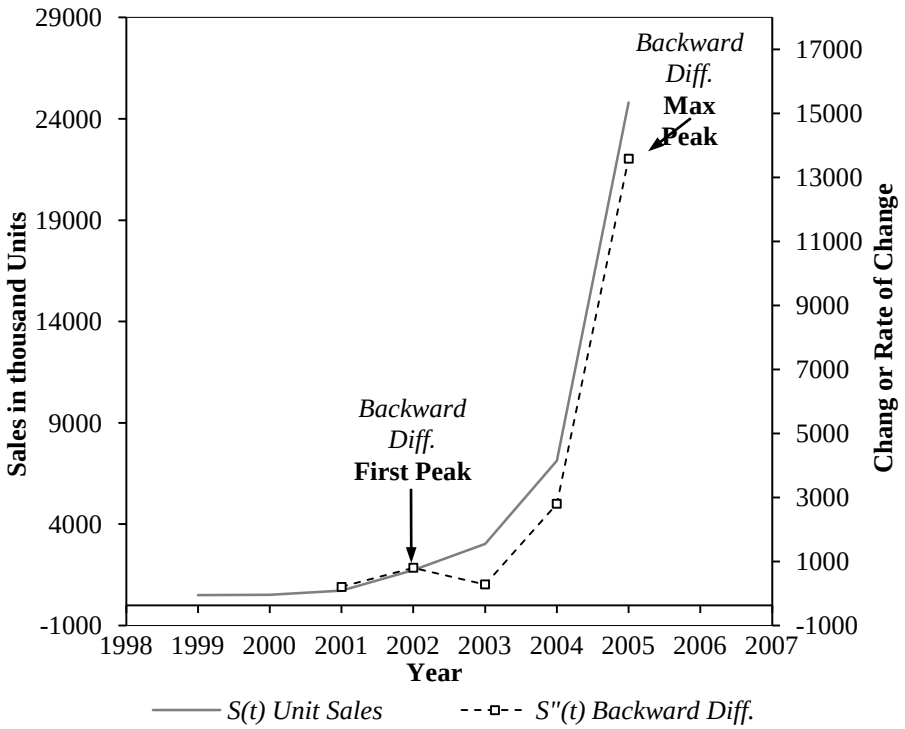


Figure 4: Multiple Takeoffs of the U.S. MP3 Players Industry under the Backward Difference Approximation.



Multiple Takeoffs

Peng (2006) pointed out that , theoretically speaking, there maybe multiple take offs in the product life cycle of an innovation. Such pheromone has been confirmed by Muller and Yogve (2006) using the market takeoff identification tool developed by Golder and Tellis (1997). Muller and Yogve (2006) observed three takeoffs in various consumer electronic industries such as PC, printers, and remote controls. The multiple-takeoff characteristic of innovations impacts our analysis profoundly.

Our identification of the peak of the rate of change on the acceleration of sales is only try to identify the *"the maximum rate of change"* on the acceleration of sales. The *"the of change"* on the acceleration of sales is naturally time-based. Therefore, the *"the maximum change"* on the acceleration of sales is contingent upon the period of time which one studies.
Given this notion, to really identify the time of market takeoff, we must examine the first peak of the curve of the rate of acceleration of sales. Figure 3 and Figure 4 show the first peak and the maximum peak of the curve under the backward difference approximation approach. We can see that the first takeoff for the PC and the MP3 player innovations are actually in 1979 and 2002 respectively.

CONCLUSTION AND DISCUSSION

Market takeoff is an important phenomenon in the course of an innovation's development. Scholars in the field of technology and innovation management had developed statistical tools (Agarwal and Bayus, 2002) and graphical tool (Golder and Tellis, 1997) to facilitate the identification of market takeoffs.

The statistical method, though rigorous, can only identify the takeoffs in the retrospect. Researchers need to collect a more complete sales data for the takeoff identifications. That is why the graphical tool developed by Golder and Tellis (1997) is being used by practitioners in the real world setting (Foster, Golder, 2004). However, we still rely on human visual confirmation for the correct identification of market takeoffs and the method still can miss-identify the market takeoffs (Golder and Tellis, 1997).

Therefore, we proposed to use the derivative approximation of finite differences method as a new market takeoff identification method. This method can identify the takeoff earlier than the traditional statistical methods given its only demand sales data of the next period. Given its numeric nature, we can identify market takeoffs objectively.

We identify 1979 as the year of market takeoff for the PC innovation. Although differ from the conclusion from Agarwal and Bayus (2002). However 1979 is one year after the introduction of the complete package of the Apple II (Peng, 2006) in the PC innovation. And 2002 is one year after the introduction of the iPod. This shows that takeoff may be closed related to the product innovation which is consist with existing diffusion literature. We still need to examine more innovations and compare the conclusions draw from the new method with existing methods to better evaluate the validity of identifying marketing using the derivative approximation of finite differences method.

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FARM INVESTMENT BEHAVIOUR: EVIDENCE FROM FRANCE, HUNGARY AND SLOVENIA

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ABSTRACT

The article investigates the investment and financial constraints for French, Hungarian and Slovenian farms using FADN panel data with different econometric estimation approaches. Farm gross investment is positively associated with real sales growth and cash flow implying the absence of soft budget constraint. Gross farm investment is positively associated with investment subsidies. Specific results by country are found depending on farm indebtedness. Investment subsidies can mitigate some capital market imperfections in short-term, while on long-term what is crucial is farm sale ability to successfully compete in the output market gaining sufficient cash flow for farm competitive survival and investment.

Keywords: farm investment, soft budget constraint, investment subsidy, panel data analysis
JEL classification: D81, D92, O12, Q12, C23

INTRODUCTION

There is a wealth of literature on the presence of capital market imperfections and their effects on firm investment in transition countries (e.g. Budina et al., 2000; Konings et al., 2003; Lizal and Svejnar, 2002; Rizov, 2004), and a few papers focusing on this issue for the agricultural sector in these countries (Petrick, 2004; Latruffe, 2005; Bojnec and Latruffe, 2007; Bakucs et al., 2009; Latruffe et al., 2010). This research provided evidence for existence of capital market imperfections during transition and after accession to the European Union (EU) (Rizov et al., 2001). In addition, some studies tested the persistence of soft budget constraint in transition economies. If soft budget constraint is still persistent, it may lead to a postponed restructuring (Kornai, 2001, Kornai et al. 2003). Soft budget constraint may be more important in agriculture because government supports to the farm sector are much higher than to firms in manufacturing. Cross-country comparison of investment behaviour is limited in the agricultural economics literature (except Benjamin and Phimister, 2002). Previous empirical analyses on investment activity in agriculture are mainly based on the augmented accelerator model or Euler equations.

The aim of this paper is to analyse the existence of soft budget constraint and credit market imperfections in three different EU countries, France, Hungary and Slovenia, using the augmented accelerator model with dynamic panel estimations. The historical development and the evolution of farms in the EU vary by countries, not only between Eastern and Western Europe, but also inside both regions. Within Eastern Europe these differentials in farm size and its growth are caused by the initial conditions that are linked to the agricultural history during the previous communist system and later institutional and policy reforms, while in Western Europe they are caused by the long-term institutional and policy evolutionary factors and market conditions. During the communist system Hungarian agriculture was collectivised and the average farm size has been all the time among the largest in Europe. In Slovenia the communist collectivisation failed and small-scale farm structure has remained among the smallest in Europe. In France farm structure has developed under market conditions and policy support, in particular the Common Agricultural Policies (CAP) measures introduced after the Second World War (Piet et al., 2010). While its farms are among the largest in Western Europe, they are smaller than in Hungary. Transition from centrally-planned to market economy in Slovenia has strengthened further development of small-scale family farms, while in Hungary a bi-modal farm structure has emerged with a greater number of small-scale family farms and a smaller number of large-scale corporate farms. The proportion of small farms in Slovenian agriculture is much higher than in Hungary. Therefore, our comparative analysis includes three countries with different historical-institutional developments and different farm structures: small-scale farms in Slovenia, medium-sized farms in France, and bi-modal small-scale and large-scale farms in Hungary.

Our analysis is based on data from the French, Hungarian and Slovenian Farm Accountancy Data Networks (FADN). Previous research has provided evidence of capital market imperfections in these countries during transition (Bojnec and Latruffe, 2007; Bakucs et al., 2009). Our paper highlights whether such imperfections persist after accession to the EU.

METHODOLOGY

The starting point of our empirical analysis is the standard augmented accelerator model in the following specification (Fazzari et al., 1988):

$$\frac{I_{it}}{K_{it-1}} = \alpha_i + \alpha_1 \frac{Q_{it}}{K_{it-1}} + \alpha_2 \frac{CF_{it-1}}{K_{it-1}} + \varepsilon_{it} \qquad (1)$$

where subscript *i* denotes the *i*-th farm and subscript *t* denotes the *t*-th period, while ε is a stochastic element. I_{it} denotes gross investment of the *i*-th farm between periods *t* and *t-1*, which is calculated as the change in capital stock (net investment) plus depreciation in values; values in period *t* were deflated by the agricultural input price index for goods and services contributing to agricultural investment K_{it-1} is the stock of capital, measured by all tangible assets, in the period *t-1*; values in the current period *t* are deflated by the agricultural input price index. Q_{it} is the change in output sales value between period's *t* and *t-1*; values in period *t* were deflated by the harmonized indices of consumer prices. CF_{it-1}

denotes the real cash flow of the *i*-th farm, defined as before tax profits plus depreciation; values in period *t* were deflated by the harmonized indices of consumer prices. Dependent and explanatory variables are normalised by the stock of capital in time *t*-1 to control for size effects.

The positive regression coefficient α_2 on the cash-flow variable is generally interpreted as a sign for credit rationing, as firstly proposed by Fazzari et al. (1988). In addition, Lizal and Svejnar (2002) suggested to consider the coefficient α_2 as an indication of the presence of the soft budget constraint, and proposed two interpretations for the latter: first, the weak version when the coefficient α_2 is zero; firms have access to credit for investment irrespective of their profitability. Second, the strong version of the soft budget constraint, when the coefficient α_2 is negative; firms with poor financial performance can access bank loans more easily.

Following Konings et al. (2003) we estimate equation (1) in first differences to control for unobserved farm level fixed effect and possible measurement error:

$$\Delta \frac{I_{it}}{K_{it-1}} = \alpha_1 \Delta \frac{Q_{it}}{K_{it-1}} + \alpha_2 \Delta \frac{CF_{it-1}}{K_{it-1}} + \Delta \varepsilon_{it} \qquad (2)$$

In our econometric estimations the baseline model is the standard augmented accelerator model (equation (2)). We then extend our model specification to include investment subsidies related to capital stock as an additional explanatory variable in a separate model.

In addition to full sample estimate, we use farm characteristics to classify farms by increasing vs. decreasing real sales, and by high debt and low debt farms. Similar as Benjamin and Phimister (2002), we define high debt and low debt farms with debt-to-asset ratio greater than 0.3 and less than 0.2 respectively, to test the sensitivity of our estimation. We also imposed outlier rules by removing farms from econometric estimates if the investment capital ratio is above 99% in absolute value (Benjamin and Phimister, 2002).

In the empirical analysis we use three econometric estimators. First, we employ standard static panel models using a Hausman test to identify whether a random or a fixed effect model is appropriate. Second, we employ the generalized method of moments (GMM) estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998), also referred to as GMM-system estimator. Windmeijer (2005) proposes a finite sample correction that provides more accurate estimates of the variance of the two-step GMM estimator. As the t-tests based on these corrected standard errors are found to be more reliable, the paper estimates the coefficients using the finite sample correction. Finally, we have an unbalanced panel dataset for the five year length period between 2003 and 2007 for France and between 2004 and 2008 for Hungary and Slovenia. Thus to correct the unbalanced nature of our data, in a third model, we estimate equation (2) with a generalised version of bias corrected LSDVC estimator proposed by Bruno (2005a)[1]. The author defines a selection indicator r_{it} such that r_{it} =1 if (y_{it}, x_{it}) is observed and r_{it} =0

[1] We apply the Stata programme xtlsdvc developed by Bruno (2005b) using Blundell and Bond (1998) estimator.

otherwise. From this the dynamic selection rule s (r_{it}, $r_{i,t-1}$) is created, that selects only the observations that are usable for the dynamic model, namely those for which both current values and one-time lagged values are observable. As it is good practice to check the sensitivity of empirical results, we will present and compare the results from the fixed effects estimator, GMM estimator, and LSDVC estimator. The French sample being too large for such estimator, it is applied to a random sample of half the size of the initial size.

DATA

The data analysis is based on French, Hungarian and Slovenian FADN that includes farms above two European Size Units (ESUs; one ESU is equivalent to 1,200 euros of gross margin). The time span used for analysis is 2004-2008 for Hungary and Slovenia and 2003-2007 for France. Table 1 presents descriptive statistics of the data used. Gross investment to capital is the highest for Hungarian and the lowest for Slovenian FADN farms, but of course varies by farms. The data shows disinvestments by some farms in Slovenia and France, but not in Hungary. Real sale growth to capital is the highest for French and the lowest for Slovenian FADN farms. Real cash flow to capital is the highest for Slovenian and the lowest for French FADN farms. Similarly as real sale growth to capital, also real cash flow to capital vary by farms from negative to positive values. Real investment subsidy in period t-1 to capital is on average similar for French, Hungarian or Slovenian FADN farms.

Table 1: Descriptive statistics for the whole period 2004-2008.

Variable		Obs	Mean	Std. Dev.	Min	Max
				Hungary (in euro)		
Investment to capital	$\frac{I_{it}}{K_{it-1}}$	8367	0.096	0.220	0.000	11.633
Sale growth to capital	$\frac{Q_{it}}{K_{it-1}}$	8367	0.253	0.230	-0.939	8.004
Cash flow to capital	$\frac{CF_{it-1}}{K_{it-1}}$	8367	0.014	0.275	-10.784	3.593
Investment subsidy in period *t*-1 to capital		8367	0.004	0.029	0.000	1.080
				Slovenia (in euro)		
Investment to capital	$\frac{I_{it}}{K_{it-1}}$	2237	0.049	0.097	-0.206	11.633
Sale growth to capital	$\frac{Q_{it}}{K_{it-1}}$	2237	0.096	0.180	-0.360	8.004
Cash flow to capital	$\frac{CF_{it-1}}{K_{it-1}}$	2237	0.031	0.182	-1.076	3.593
Investment subsidy in period *t*-1 to capital		2237	0.004	0.022	0.000	1.080
				France (in euro)		

Investment to capital	$\frac{I_{it}}{K_{it-1}}$	25782	0.076	0.174	-3.440	12.500
Sale growth to capital	$\frac{Q_{it}}{K_{it-1}}$	25782	0.299	0.292	-0.729	12.049
Cash flow to capital	$\frac{CF_{it-1}}{K_{it-1}}$	25782	0.131	0.246	-12.325	9.370
Investment subsidy in period *t*-1 to capital		25782	0.004	0.019	0.000	0.868

ECONOMETRIC RESULTS

Results of the Hausman test suggest using fixed effect models. The standard augmented accelerator model confirms a positive association between farm investment and real sale growth and cash flow variables, respectively (Table 2). Therefore, our econometric results reject the validity of the soft budget constraint for French, Hungarian and Slovenian farms. However, they reveal the presence of capital market imperfections. Farm investments are positively associated with investment subsidies in time *t* in France, Hungary and Slovenia, but negatively for investment subsidies in time *t-1* for France and Hungary. This implies that current investment subsidies are important for investment decisions, but except for Slovenia, they are not anticipated as a factor for long-term farm investment behaviour, where a more crucial role is plaid by farm output market conditions with real sales to growth and cash inflow into the farm household.

Table 2: Fixed effect model results for the full samples.

	Standard augmented accelerator model (equation (1)) Full sample	Including investment subsidy at *t* Full sample	Including investment subsidy at *t*-1 Full sample
HUNGARY			
Sale growth $_{t,t-1}$	0.126***	0.147***	0.125***
Cash flow $_{t-1}$	0.085***	0.079***	0.081***
Investment subsidy		2.543***	-0.173**
Constant	0.056***	0.042***	0.058***
N	5911	5911	5911
R^2	0.0015	0.1134	0.0011
Hausman test (p-value)	0.0000	0.0000	0.0000
SLOVENIA			
Sale growth $_{t,t-1}$	0.314***	0.267***	0.327***
Cash flow $_{t-1}$	0.076***	0.081***	0.075***
Investment subsidy		1.450***	0.527**
Constant	0.022***	0.020***	0.019***
N	1407	1407	1407
R^2	0.1192	0.2049	0.1306
Hausman test (p-value)	0.0000	0.0000	0.0000
FRANCE			
Sale growth $_{t,t-1}$	0.191***	0.188***	0.189***
Cash flow $_{t-1}$	0.188***	0.185***	0.187***
Investment subsidy		1.633***	-0.668***
Constant	-0.009**	-0.014***	-0.005
N	16992	16992	16992
R^2	0.0157	0.0328	0.0142
Hausman test (p-value)	0.0000	0.0000	0.0000

Dependent variable: gross investment$_{t,t-1}$ to capital. All explanatory variables are divided by capital. N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels.

Following Benjamin and Phimister (2002) we impose outlier rules to exclude farms if their investment to capital ratio is above 99% in absolute value (Table 3). The results do not change substantially. The regression coefficients for real sale growth are of a positive sign and significant in all specified cases. The regression coefficients for the cash flow variable remains with the positive sign. For Slovenia, the regression coefficients are slightly lower and closer to zero. The regression coefficients for investment subsidy in the current period *t* are of a positive sign and significant, but the coefficients for investment subsidy in the previous period *t-1* are not significant for Hungary and Slovenia, and negative and significant for France.

Table 3. Fixed effect model results for the full samples without farms for which the investment capital ratio is above 99% in absolute value

	Standard augmented accelerator (equation (1))	Including investment subsidy at *t*	Including investment subsidy at t-1
HUNGARY			
Sale growth $_{t,t-1}$	0.101***	0.118***	0.101***
Cash flow $_{t-1}$	0.053***	0.050***	0.052***
Investment subsidy		2.381***	-0.044
Constant	0.057***	0.045***	0.058***
N	5883	5883	5883
R^2	0.0016	0.1106	0.0014
Hausman test (p-value)	0.0000	0.0000	0.0000
SLOVENIA			
Sale growth $_{t,t-1}$	0.339***	0.282***	0.337***
Cash flow $_{t-1}$	0.023*	0.030**	0.022*
Investment subsidy		1.231***	-0.292
Constant	0.018***	0.018***	0.019***
N	1403	1403	1403
R^2	0.1316	0.2221	0.1279
Hausman test (p-value)	0.0000	0.0000	0.0000
FRANCE			
Sale growth t,t-1	0.126***	0.125***	0.125***
Cash flow t-1	0.052***	0.052***	0.052***
Investment subsidy		1.260***	-0.375***
Constant	0.022***	0.018***	0.025***
N	16940	16940	16940
R2	0.0142	0.0351	0.0121
Hausman test (p-value)	0.0000	0.0000	0.0000

Dependent variable: gross investment$_{t,t-1}$ to capital. All explanatory variables are divided by capital. N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels.

Moreover, we split our FADN sample into two sub-samples depending on farm indebtedness to classify farms as high debt vs. low debt farms that can be considered to differ in their financial constraints. Similar as Benjamin and Phimister (2002) we define high debt and low debt farms with debt-to-asset ratio greater than 0.3 and less than 0.2, respectively.

The results differ by countries and by these two debt groups of farms. For France, gross farm investment is positively and significantly associated with real sale growth in the current period *t* for both groups of farms with high and farm with low debts (Table 4). This finding holds also for farms with low debt in Hungary and Slovenia, but the regression coefficients for these two countries are insignificant for high debt farms. While investments in low debt farms are market driven, it is less clear for high debt farms in Hungary and Slovenia.

Table 4: Fixed effect model results for the sub-samples depending on farm indebtedness.

	Standard augmented accelerator (equation (1)		Including investment subsidy at *t*		Including investment subsidy at *t-1*	
	Farms with high debt	Farms with low debt	Farms with high debt	Farms with low debt	Farms with high debt	Farms with low debt
HUNGARY						
Sale growth $_{t,t-1}$	0.073	0.160***	0.100**	0.172***	0.074	0.160***
Cash flow $_{t-1}$	0.097***	0.169***	0.102***	0.162***	0.102***	0.172***
Investment subsidy			2.774***	2.258***	0.181	0.085
Constant	0.101***	0.033***	0.078***	0.024***	0.100***	0.032***
N	1214	3939	1214	3939	1214	3939
R^2	0.0065	0.0085	0.0637	0.0876	0.0056	0.0090
SLOVENIA						
Sale growth $_{t,t-1}$	0.271	0.337***	0.982	0.325***	0.288	0.335***
Cash flow $_{t-1}$	1.128***	0.023*	1.091**	0.031***	1.120***	0.023*
Investment subsidy			-2.061	1.135***	0.331	-0.470**
Constant	0.041	0.018***	-0.074	0.014***	0.036	0.020***
N	20	1361	20	1361	20	1361
R^2	0.3203	0.1211	0.3734	0.2189	0.3225	0.1125
FRANCE						
Sale growth t,t-1	0.220***	0.240***	0.218***	0.238***	0.215***	0.240***
Cash flow t-1	0.062***	0.589***	0.060***	0.587***	0.0622***	0.589***
Investment subsidy			1.543***	1.634***	-1.184***	0.045
Constant	0.009*	- 0.093***	0,003	-0.097	0.016***	- 0.093***
N	9939	4302	9939	4302	9939	4302
R2	0.0268	0.0028	0.0573	0.0048	0.023	0.0029

Dependent variable: gross investment$_{t,t-1}$ to capital. All explanatory variables are divided by capital. N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels.

The regression coefficients for the cash flow variables, irrespective to the model specification, are of a positive sign and significant implying an absence of soft budget constraint but a presence of capital market imperfections. In Hungary and France, the coefficient is much higher for farms with low debt than for farms with high debt, revealing that lower indebtedness constrains more investment decisions in these countries. However, the opposite is found for Slovenia. The regression coefficients for the investment subsidy variable are mixed. They are of a positive sign and significant when pertaining to investment subsidy at time *t* for Hungary and France as well as for Slovenia in the case of farms with low debt. On the contrary, for Hungary they are insignificant for lagged investment subsidy variable. For Slovenia, for high debt farms the regression coefficient pertaining to lagged investment subsidy variable is insignificant, while for low debt farms they are significant, but of a negative sign. The opposite holds for French FADN farms: of a negative sign and significant for farms with high debt and insignificant for farms with low debt. The regression coefficients for the lagged investment subsidy variables imply different long-term

investment behaviour of farm by countries and by the degree of indebtedness of farms. While for Hungary there is less significant long-term farm investment behaviour for these two groups of farms, the Slovenian low debt farms and French high debt farms seem to be a cautious in their long-term farm investment behaviour.

Table 5: Dynamic Panel Model (GMM-SYS) results for the full sample.

	Standard augmented accelerator (equation (2))	Including investment subsidy at *t*
HUNGARY		
Sale growth $_{t,t-1}$	0.233***	0.227***
Cash flow $_{t-1}$	0.529***	0.457***
Investment subsidy		2.954***
Constant	-0.027*	-0.030**
N	5911	5911
Wald test (p-value)	0.0000	0.0000
Sargan test (p-value)	0.5729	0.1741
SLOVENIA		
Sale growth $_{t,t-1}$	0.320***	0.252**
Cash flow $_{t-1}$	0.074	0.054
Investment subsidy		0.946***
Constant	0.013	0.018
N	1407	1407
Wald test (p–value)	0.0043	0.0004
Sargan test (p-value)	0.0250	0.0197
FRANCE		
Sale growth $_{t,t-1}$	0.233***	0.226***
Cash flow $_{t-1}$	0.233***	0.212***
Investment subsidy		1.772***
Constant	-0.035**	-0.035***
N	16992	16992
Wald test (p–value)	0.0000	0.0000
Sargan test (p-value)	0.3443	0.3760

Dependent variable: gross investment$_{t,t-1}$ to capital. All explanatory variables are divided by capital. N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels.

The re-estimated adapted standard augmented models by the dynamic panel data model (GMM-SYS) confirm the positive and significant association between farm gross investment and farm real sale growth (Table 5). These results clearly imply that the FADN farm investment behaviour are driven by competitive output market conditions and the farm abilities to sell output and invest in such a market environment. Moreover, except for Slovenia, farm gross investment is positively and significantly associated with cash flow, confirming for France and Hungary the absence of the soft budget constraints for the FADN farms. For Slovenia, the regression coefficients for the cash flow variable are insignificant. Finally, farm gross investment is found to be a positively and significantly associated with investment subsidies for France, Hungary and Slovenia. To sum up, these GMM-SYS results

reject the validity of the soft budget constraints for French and Hungarian FADN farms and confirm the presence of capital market imperfections in these two countries.

The sample selection models based on the bootstrapped standard errors estimates provide all significant regression parameters at 1% significance level except for cash flow coefficient in France (Table 6). The positive association between gross farm investment and real sale growth is confirmed in all three countries, confirming that farms based their investment decisions on market conditions. The positive association between gross farm investment and cash flow also rejects the validity of the soft budget constraints but confirms the presence of capital market imperfections in Hungary and Slovenia. No significance is found for the French sample. Finally, gross farm investment is positively associated with investment subsidies in the three countries.

Table 6: LSDVC sample selection models results for the full sample.

	Standard augmented accelerator (equation (2))	Including investment subsidy at *t*
HUNGARY		
Sale growth $_{t,t-1}$	0.154***	0.175***
Cash flow $_{t-1}$	0.228***	0.233***
Investment subsidy		2.656***
N	5883	5883
SLOVENIA		
Sale growth $_{t,t-1}$	0.314***	0.279***
Cash flow $_{t-1}$	0.063***	0.065***
Investment subsidy		1.471***
N	1407	1407
FRANCE (half sample)		
Sale growth $_{t,t-1}$	0.182***	0.174***
Cash flow $_{t-1}$	0.024	0.029
Investment subsidy		2.360***

Dependent variable: gross investment$_{t,t-1}$ to capital. All explanatory variables are divided by capital. N: number of observations. ***/**/*: statistically significant, respectively at the 1%, 5%, and 10% levels, based on bootstrapped standard errors with 500 replications.

CONCLUSION

We use an adapted augmented accelerator model of gross farm investment for a panel data of French, Hungarian and Slovenian FADN farms to investigate the impact of real sale growth, cash flow and investment subsidy on gross farm investment, during the period 2003-2007 for France and 2004-2008 for Hungary and Slovenia. We use different econometric estimation approaches to test the sensitivity and robustness of our econometric results.

In a spite of different nature of FADN farms in France, Hungary and Slovenia, their investment behaviour does not differentiate substantially. Farm gross investment is positively associated with real sale growth suggesting that farm investment decisions are

based on market conditions in all the three countries. The association is also of a positive sign for the cash flow variable in general, implying the absence of the soft budget constraints and the presence of capital market imperfections limiting investment expenditures. As expected, some differentials are also found between farms with low and high debts, which vary between the analysed countries. Gross farm investment is positively associated with investment subsidies. Public programmes to support farm investment (investment subsidies) seem to be successful in enhancing investment in these countries in short-term, but farms investment behaviour pertaining to investment subsidies is more cautious on long-term. This implies that investment subsidies can mitigate some capital market imperfections such as interest rate volatility, but on long-term what is crucial is farm competitiveness and ability to successfully compete in the output market gaining sufficient cash flow for farm competitive survival and investment and thus also farm growth.

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FINANCIAL INSTRUMENTS USAGE AND STRATEGIC EARNINGS REPORTING – THE COMPLEMENT HYPOTHESIS EXAMINATION

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ABSTRACT

The purpose of this study is to examine whether listed firms in Taiwan use discretionary accruals and financial instruments regulated under Statement of Financial Accounting Standards No.34 as complement tools in reporting earnings. We estimate a set of simultaneous equations that captures managers' incentives to enhance earnings performance through financial instruments usage and accrual management. The empirical results of two-stage least squares regressions reveal that, as conjectured, the financial instruments usage is positive associated with the magnitude of discretionary accruals and support the complement hypothesis. It suggests that managers jointly use financial instruments and discretionary accruals to increase earnings and, besides the risk hedging purpose, provides alternative explanation for the multi-goals of financial instruments usage. These results remain robust to various specification tests.

Keywords: Complement hypothesis, Discretionary accruals, Earnings management, Financial instruments usage,

INTRODUCTION

The participants in financial derivatives market include hedgers, speculators and arbitrageurs. Hedgers use financial instruments to lock-in prices in order to avoid exposure to adverse movements in the price of an asset. Speculators take short-term positions in the market and consider derivatives as instruments of profit making, instead of as risk hedging tools. The arbitrageurs enter simultaneously into contracts in two or more markets to lock-in riskless profit by exploiting price differentials or imbalances. Nonetheless, how financial instruments are actually used by non-financial firms is still largely unknown in the literatures. Although firms can use financial instruments to speculate and/or to arbitrage on private information, extant empirical studies highlight the risk hedging motive and ignore the important roles of the other two participants.

The purpose of this study is to examine the possible complement relationship between the financial instruments usage and aggressive discretionary accruals in enhancing earnings (hereafter, the complement hypothesis) for listed firms who recognized the usage of financial instruments regulated under Statement of Financial Accounting Standards (SFAS) No.34 (Financial Accounting Standards Board 2004) in Taiwan. Before the enactment of SFAS No.34, firms only disclosed some of the financial instruments information in the footnotes and these disclosures were not uniform. Therefore, there was a lack of visibility or transparency for financial instruments usage. Because SFAS No. 34 requires firms to recognize all financial instruments as assets or liabilities in the balance sheet and also requires them to adopt mark to market approach to recognize the resulting gains or losses from the changes of financial instruments' fair value at the end of fiscal year in their income statements. Thus, the magnitude of financial instruments usage to some extent would have an effect on listed firms' reported earnings. Rather, the active usage of financial instruments is thought to add value by alleviating a variety of market imperfections through hedging (Adam & Fernando, 2006). Recently, Gèczy et al. (2007) suggest that financial derivatives involve real action which plays an important role in strategically boosting firm's earnings and view speculation as a positive profitability activity. Inspired by the study of Gèczy et al. (2007), the present study is motivated to examine whether listed firms jointly use financial instruments and discretionary accruals to manipulate their earnings.

Since earnings have two components, cash flows from real operations and accruals, the earnings reporting choices can result from cash flows and/or accruals. Facing increasing pressure to meet benchmark earnings, managers have incentives to use both discretionary accounting choices and real operation activities, such as using financial instruments, to manipulate earnings. In other words, except using the discretionary accrual, managers also can manipulate earnings through purchase and/or sell financial instruments. Recently, Gèczy et al. (2007) suggest that financial derivatives can be used to hedge market risk exposures or to speculate on movements in the value of the underlying asset. The authors argue that the speculation hypothesis generally implies that the derivative transactions are undertaken with the primary intention of making a profit. Adam & Fernando (2006) also document that gold mining firms have consistently realized economically significant cash flow gains from their derivatives transactions. Thus, if managers rather use financial instruments to increase earnings (and/or cash flow) but to smooth earnings, the substitution relationship between financial instruments usage and discretionary accruals is called for

further examinations.

Recent studies document that managers' market views influence their attempting to time commodity markets with derivatives usage decisions (Stulz, 1996; Faulkender, 2005; Brown et al., 2006; Adam & Fernando, 2006). Stulz (1996) calls this practice "selective hedging". He claims that selective hedging will increase shareholder value if managers have an informational advantage relative to other market participants. Thus, it is possible that managers believe that they can create shareholder value by incorporating speculative elements into their financial instruments usage decisions. Hitherto, many studies view discretionary accruals as the primary tools to manipulate earnings. However, managers also can increase earnings by using financial instruments that boost their firms' cash flows. Once managers believe they have a comparative information advantage relative to the market and, hence, to view speculation as a positive profitability activity, the magnitude of financial instruments usage will be enlarged. In such case, financial instruments usage will play an important role in strategically boosting firm's earnings. It is expected that both the financial instruments usage and aggressive discretionary accruals play important roles in elucidating firms' income-increase reporting behaviors. Inspired by the studies of Adam & Fernando (2006), Gèczy et al. (2007) and among others which view speculation as a positive profitability activity, the present study examine the possible complement relationship between the financial instruments usage and aggressive discretionary accruals in enhancing earnings for listed firms with active financial instruments usage under SFAS No.34 in Taiwan.

The empirical results of the two-stage least squares regression indicate that, as conjectured, financial instruments usage is positive association with the magnitude of discretionary accruals and supports the complement hypothesis. It suggests that managers use financial instruments and discretionary accruals jointly to increase earnings, which is inconsistent with the studies of Barton (2001) and Wang & Kao (2005). Reporting requirements on financial instruments usage may potentially affect firms' behavior with respect to production and risk management, and thus the derivative instruments usage. Sapra (2002) demonstrates that it is possible for mandatory financial instruments disclosures to result in excessive speculation in the financial instruments market. Our empirical results to some extent evidence the possible potential multi-purposes of financial instruments usage and support the findings of Sapra (2002). These results remain robust to various specification tests.

Overall, the present study documents that financial instrument has cash flows effect, then influence reporting earnings, and provides feedback for regulators with respect to the subsequent reporting requirement in capital market. The present study enriches the financial instruments related research from two angles. First, although Barton (2001) finds that derivatives serve as a partial substitute role to discretionary accruals subject to managers' income smoothing assumption, the potential cash flows effect of financial instruments can be a potentially important motive for firms to use financial instruments. We examine whether financial instruments usage is a complement tool for discretionary accruals to manipulate earnings. The second angle, this study contributes to the literature by examining, besides the prevailing hedging risk hypothesis, financial instruments can be used to speculate on movements in the value of the underlying asset. If managers can boost earnings by using multiple tools, i.e., financial instruments and aggressive discretionary

accruals, the question naturally arises regarding how managers combine these instruments to gain benefits. This examination, to some extent, provides evidence to understand the substitute or complement nature of financial instruments usage strategy in earnings increase and assists regulators to evaluate the possible policy effect of SFAS No. 34 in Taiwan.

This paper is organized as follows: Section 2 describes the related prior studies and develops the empirical hypothesis. Section 3 presents the empirical design. Section 4 presents and discusses the empirical results. Section 5 discusses the robustness test and Section 6 concludes the study.

BACKGROUND AND LITERATURE REVIEWS

Accounting for Financial Instruments in Taiwan

The ongoing growth in the use of financial instruments accompanying with the financial instruments abuses have motivated accounting regulators to develop and stretch financial instrument-related disclosure requirements in Taiwan. First, The Financial Accounting Standards Committee of the Accounting Research and Development Foundation in Taiwan issued SFAS No.14 regulating the accounting treatments of *Foreign Currency Translation* transactions in December 1998. Subsequently, SFAS No.27 (*Disclosure of Financial Instruments*) was issued in 1997 and aimed to improve the transparency of listed firms' financial instruments usage. Namely, it required the disclosure of the extent (i.e., the contractual or notional amount), nature, terms, and the concentrations of credit risk for all financial instruments. Since the requirements of disclosing of financial instruments were not clear and uniform, the disclosures about financial instruments in financial statement are obscure and discretionary. SFAS No.34, *Accounting for Financial Instruments*, was issued in December 2004 and was effective for fiscal years beginning after 2006. This new standard requires all financial instruments owned by the listed companies to be initially recognized in the balance sheet as either liabilities or assets at their fair values. It also requires them to adopt mark to market approach to recognize the resulting gains or losses from financial instruments' fair value changes at the end of fiscal year in their income statements or in equity section of the balance sheet, depending on the intentions of financial instruments usage and the types of hedging. This standard setting provides the present study with a unique opportunity to identify a distinct financial instruments users sample that recognized financial instruments in their annual reports during 2006~2007 to examine the alternative motivation of financial instruments usage, besides the risk hedging motivation.

Related Research

Firms normally make plans based on expectations of what foreign exchange rates, interest rate, and commodity prices will be over the near time. If prices or rates change, the result of operations and cash flows will also differ from expectations. When firms have incentives to reduce the volatility of cash component of earnings through real risk-management activities, one possible way is to use derivatives to hedge the risks inherent in commodity prices,

foreign currencies, and interest rate (Nance et al., 1993; Tufano, 1996; Gèczy et al., 1997). That is, firms can use properly structured hedging derivative forms, whose rate or price moves in the opposite direction of the rate or price of the underlying item being hedged, to reduce the magnitude of differences. Breeden & Viswanathan (1998) find that hedging reduces noise related to exogenous factors and hence decreases the level of asymmetric information regarding a firm's earnings and its quality. This finding again is supported by the study of Dadalt et al. (2002). There are substantial studies examining the using of derivatives to smooth earnings/cash flows volatilities. For examples, Smith & Stulz (1985) show that the use of derivatives to hedge can maximize shareholder value because hedging may be reduce expected tax and expected costs of financial capital by reducing the probability that the firm encounters financial distress. In advance, there are rich bodies of studies exploring the various channels through which financial derivatives hedging can contribute to increase firm value (e.g., Froot et al., 1993; DeMarzo & Duffie, 1995; Allayannis & Ofek, 2001; Graham & Rogers, 2002). It seems the usage of financial derivatives is associated not only with smoothing earnings but also with enhancing firm's value.

Another line of research examines the tradeoffs managers make between derivatives and other risk management tools. For example, Schrand & Unal (1998) document that managers of thrift institutions integrate derivatives and the composition of loan portfolios to manage overall risk. Petersen & Thiagarjan (2000) using gold mining companies and Pincus & Rajgopal (2002) using oil & gas firms as sample examine the interaction of accounting choice and derivatives hedging and evidence similar tradeoffs pattern. Barton (2001) uses sample firms of *Fortune 500* non-financial companies and estimates a set of simultaneous equations that captures managers' incentives to maintain a desired level of earnings volatility through hedging and accrual management. The author concludes that managers use derivatives and discretionary accruals as partial substitutes for smoothing earnings. Following Barton (2001), Wang & Kao (2005) based on Taiwanese listed companies sample also find the substitution relationship between discretionary accruals and derivatives in earnings smoothing. However, the finding of Wang & Kao (2005) is based on SFAS No.27 (*Disclosure of Financial Instruments*) and on relative small hand-collected sample size (109 sample firms with 327 firm-year observations). Their underlying premise is also based on the comparative cost and benefit of discretionary accruals and derivatives as Barton' (2001) U.S. capital market setting. Recently, Kim et al. (2006) examine whether operational hedging (firms reporting foreign sales) can be viewed as either a substitute or a complement role to financial derivatives hedging when a firm intends to reduce the volatility of future cash flows and, thus, to possibly increase firm value. The authors find that non-operationally hedged firms use more financial hedging relative to their level of foreign currency exposure and suggest operational hedging is complement to financial derivatives hedging. According to above, to some extent, managers have incentives to smooth and/or enhance earnings and financial instruments can be an effective tool to meet their earnings management goals.

Hypothesis Developments

Prior studies document that financial instruments can be treated as a mean to strategically manipulate firm's earnings. Barton (2001) and Wang & Kao (2005) propose the income smoothing hypothesis and suggest both derivatives and discretionary accruals can be used for reducing earnings volatility. Recently, Adam & Fernando (2006) suggest that the active

usage of derivatives is thought to create firm value by alleviating a variety of market imperfections through hedging. Gèczy et al. (2007) also point out that derivatives can be undertaken with the intention of making a profit. Based on the above arguments, financial instruments usage can be viewed as either a substitute or a complement tool to a firm's discretionary accruals when it intends to reduce a firm's volatility of future cash flows or to possibly increase a firm's earnings. In the income smoothing hypothesis, it is expected that financial instruments usage can be partially substituted by the use of discretionary accruals. As for the earnings increasing hypothesis, it is expected that financial instruments usage is a complement tool to the use of discretionary accruals. Thus, that the goal of strategically uses of financial instruments is earnings smoothing or earnings increasing, to some extent, is an empirical issue in differential capital market setting.

Although Ewert & Wagenhofer (2005) develop an analytical model and demonstrate that real activities manipulation increases when tightening accounting standards make accruals management more difficult. However, accruals management and real activities manipulation (e.g., financial instruments usage) are not mutually exclusive strategies for managers and multiple tools can achieve the same earnings objective. Firms can use both accruals management and real activities manipulation to boost or constrain earnings and obtain the greatest effect through a coordinated approach (Mizik & Jacobson 2007, 2008). In other words, both accruals management and financial instruments manipulation play important roles in concurrently strategically boosting and/or suppressing firm's earnings.

As for the relative cost determination of alternative earnings management tools, prior studies show that the reporting and/or litigation costs in U.S. are relatively higher than that in other developed economies (e.g., Antle et al., 1997). The higher reporting and/or litigation costs bring about the cost-benefit consideration of accruals management and financial instruments usage manipulation an important issue in managers' strategic earnings reporting decisions. However, the relative cost-benefit of accruals management and financial instruments usage manipulation bonded by the lower reporting and/or litigation costs may make the earnings management incentives effect dominate the relative cost-benefit effect, and then, weaken the effect of cost determination in the selection decisions of alternative earnings management tools. Yet, the institutional consideration for managers to incorporate the relative cost-benefit of alternative manipulating tools into strategic earnings reporting decisions are likely to be less in Taiwan, where reporting and litigation costs are relatively lower.[1] Thus, without higher reporting and litigation costs to trigger the relative cost-benefit advantage consideration between accruals management and financial instruments usage manipulation, we expect the earnings management incentives effect will dominate the relative cost-benefit effect in managers' accruals management and financial instruments usage manipulation decisions.

Stulz (1996) documents that managers' market views influence their attempting to time commodity markets with financial derivatives usage decisions. The author claims that selective hedging will increase shareholder value if managers have an informational

[1] Taiwan is characterized as a smaller stock markets, weaker investor protections, and lower disclosure requirements (Chin et al., 2009). Chin et al. (2007) and Duh et al. (2009) also documented that the auditor litigation costs in Taiwan are lower than those in other developed economies. Thus, both the lower disclosure requirements and auditor litigation costs form a somewhat relative weaker financial reporting costs environment.

advantage relative to other market participants. Thus, it is possible that managers believe that they can create shareholder value by incorporating speculative elements into their financial instruments decisions. Sapra (2002) suggests that greater transparency about a firm's derivative activities is not necessarily a panacea for imprudent risk management strategies. The author shows that transparency actually induces the firm to take excessive speculative positions in the derivative market. In other words, after SFAS No.34 is enforced in Taiwan, once managers believe they have a comparative information advantage relative to the market and, hence, view speculation as a positive profitability activity, the magnitude of financial instruments usage will enlarge. In such situation, besides the aggressive discretionary accruals, financial instruments usage, involving real actions which have cash flows effects, play an important role in strategically boosting firm's earnings. It is expected that both the financial instruments usage and aggressive discretionary accruals play important roles in elucidating firms' income-increase reporting behaviors. Inspired by the studies of Sapra (2002), Adam & Fernando (2006), Gèczy et al. (2007) that view financial instruments usage as positive profitability activities, the present study conjectures that firms with active financial instruments positions will simultaneously use discretionary accruals to boost their earnings. Namely, this study examines the complement relationship between the financial instruments usage and aggressive accruals management in enhancing earnings. From the above discussions, we therefore establish our hypothesis as follows:

H1: The financial instruments usage regulated by SFAS No.34 is positive association with the magnitude of discretionary accruals.

RESEARCH DESIGN

Data and Sample Selection

Years 2006 and 2007 are chosen as the observation years because SFAS No.34 was enforced on 2006 and later annual reports in Taiwan. The sample firms used in this study are composed of publicly traded companies listed on the Taiwan Stock Exchange (hereafter, TSE) and Gre Tai Securities Market (hereafter, OTC) in Taiwan. That only TSE-listed and OTC-listed firms are considered is due to the feasibility of collecting the necessary reliable data. The empirical data are retrieved from both the Taiwan Economic Journal Database (TEJ) and the Open Market Observation Post System (MOPS) of the TSE and OTC in Taiwan.

Because there are insufficient sample firms in some industries for estimating discretionary accruals, except food (code 12), textile (code 14) electronic (codes 23, 24, 30) industries, we follow the study of Chang et al. (2003) and group some resembling industries into one integrated industry to obtain larger firm sample and avoid the inefficiency problem of regression coefficients estimation. Electric machinery (code 15) and electric wire (code 16) are combined as "electric" industry; plastics (code 13), chemical (code 17), and rubbery (code 21) are combined as "plastic and chemical" industry; cement (code 11), iron (code 20), and construction (code 25) are combined as "construction and building materials" industry; tourism (code 27) and general merchandise (code 29) are combined as "service and sales" industry. Table 1 reports the resulted seven industries in the study.

Table 2 presents the sample selection process of the present study. Consistent with extant

literature, finance-related institutions (codes 2801 to 2888) are excluded as they are subject to different disclosure requirements and regulations that make using industry cross-sectional Jones model to estimate discretionary accruals problematic. The total observations of firms traded in TSE and OTC during 2006~2007 are 2,459 firm/years. The present study follows the study of Chang et al. (2003) and deletes glass-ceramic, paper, automobile industries, shipping and transport industry, oil industry, and other industries because of too few listed firms causing trouble in estimating discretionary accruals. We also deleted 394 observations for data deficient or unavailable. These selection procedures yield a final sample of 1,834 firm/years, which include 837 firms in year 2006 and 997 firms in year 2007, respectively.

Table 1: Integrated Industry Analysis.

Integrated or Individual Industry	Industry Composition
Construction and Building Materials (11,20,25)	Construction, Steel, and Building
Plastic and Chemical (13,17,21)	Plastic, Chemical, Rubber and Tire
Electric (15,16)	Electric Machinery, Electric Wire and Cable
Service and Sales (27,29)	Tourism and General Merchandise
Electronic (23, 24, 30)	Electronic
Foods (12)	Foods
Textile (14)	Textile and Fiber

Table 2: Sample Selection.	2006	2007	Total
Firms listed on TSE and OTC during 2006~2007	1,229	1,230	2,459
Less:			
Too few listed firms industry:			
Shipping and Transport industry	(22)	(22)	(44)
Oil industry	(12)	(12)	(24)
Paper industry	(7)	(7)	(14)
Glass and Ceramic industry	(7)	(5)	(12)
Automobile industry	(5)	(5)	(10)
Other industries	(64)	(63)	(127)
Firms' data unavailability:	(275)	(119)	(394)
Final samples	837	997	1,834

Variables Measurement and Empirical Model

This section presents the methodology implementing to examine the hypothesis. Since the usage of financial instruments regulated by SFAS No.34 and discretionary accruals may be endogenous, the simultaneous equations are developed to avoid bias and the inconsistent coefficients estimation of ordinary least squares (OLS). Following Barton (2001) and Wang & Kao (2005), the relationship between financial instruments usage and discretionary accruals is tested by the following simultaneous equations estimated by two-stage least squares (2SLS) regression. To test our hypothesis, the present study uses the following simultaneous equations:

$$|\mathbf{DIC}|_{it} = \alpha_0 + \alpha_1 \mathbf{DER}_{it} + \alpha_2 \mathbf{COMP}_{it} + \alpha_3 \mathbf{STOCK}_{it} + \alpha_4 \mathbf{DEBT}_{it} + \alpha_5 \mathbf{RD}_{it} + \alpha_6 \mathbf{FS}_{it} + \alpha_7 \mathbf{IDR}_{it} + \alpha_8 \mathbf{IND}_{it} + \alpha_9 \mathbf{DPR}_{it} + \alpha_{10} \mathbf{FLEX}_{it} + \alpha_{11} |\mathbf{OCF}|_{it} + \alpha_{12} \mathbf{ROA}_{it} + \alpha_{13} \mathbf{SIZE}_{it} + \alpha_{14} \mathbf{MILLS}_{it} + \zeta_{it} \quad \text{.....(1)}$$

and

$$\mathbf{DER}_{it} = \beta_0 + \beta_1 |\mathbf{DIC}|_{it} + \beta_2 \mathbf{COMP}_{it} + \beta_3 \mathbf{STOCK}_{it} + \beta_4 \mathbf{DEBT}_{it} + \beta_5 \mathbf{RD}_{it} + \beta_6 \mathbf{FS}_{it} + \beta_7 \mathbf{IDR}_{it} + \beta_8 \mathbf{IND}_{it} + \beta_9 \mathbf{QR}_{it} + \beta_{10} \mathbf{CYCLE}_{it} + \beta_{11} \mathbf{DIV_YIELD}_{it} + \beta_{12} \mathbf{ST_DEBT}_{it} + \alpha_{13} \mathbf{MILLS}_{it} + \xi_{it} \quad \text{.....(2)}$$

where:

$|\mathbf{DIC}|$ and $\mathbf{DER}$ are the proxies for discretionary accruals and financial instruments usage regulated by SFAS No.34, respectively. In simultaneous equations, $|\mathbf{DIC}|$ and $\mathbf{DER}$ are endogenous variables, concurrently, the other variables are control variables and will be defined in section 3.3. Furthermore, the possible self-selection problem is corrected by adding the inverse Mills ratio (MILLS) variable, which suggested by Heckman (1979), into the simultaneous equations.

Because the sample firms do not have sufficient time series data to estimate the parameters of the Jones (1991) model when determining $|\mathbf{DIC}|$, we measure discretionary accruals (DA) via the cross-sectional version of the Jones (1991) model as reported in DeFond & Jiambalvo (1994)[2]. Subramanyam (1996) and *Bartov et al.* (2001) indicate that this approach is generally better specified than the time-series model. Recently, Kothari et al. (2005) suggest that incorporating a performance measure into Jones model to estimate the parameters of the nondiscretionary accruals can effectively enhance the model specification. Therefore, we estimate the discretionary accruals (DA) by the prediction errors from the cross-sectional Jones model of Kothari et al. (2005). As discussed above, we follow the study of Chang et al. (2003), grouping some resembling industries into one integrated industry to come up with a larger sample, thus to avoid the inefficiency of regression coefficients estimation when getting the estimates of nondiscretionary accruals.

The financial instruments regulated by SFAS No.34 include: financial assets/liabilities at fair value through profit or loss, held-to-maturity investments, available-for-sale financial assets, hedging derivative assets/liabilities, financial assets/liabilities carried at amortized cost, financial assets carried at cost. Thus, in order to catch the earnings management intention of the financial instruments usage, our second pivotal variable DER is measured as the change in sum of notional amount of financial assets and financial liabilities regulated by SFAS No.34 scaled by lagged total assets. It is described as follows:

$$\mathbf{DER} = \left(\mathbf{TFA}_{it} - \mathbf{TFA}_{it-1}\right) / \mathbf{A}_{it-1}$$

[2] The modified Jones model proposed by Dechow et al. (1995) is also used to enhance the robustness of our study. The result is discussed in the robustness check.

where:

TFA is defined as the sum of notional amount of total financial assets plus total financial liabilities regulated by SFAS No.34. According to the definition, the DER may be positive or negative. Positive DER indicates that there is an increasing usage of financial instruments regulated by SFAS No.34. On the other coin, negative DER reveals that there is a decreasing usage of financial instruments regulated by SFAS No.34.

Definitions of Control Variables

Inverse Mills Ratios

To measure the inverse Mills ratio, we first estimate the following equation to explain the decision to use financial instruments:

$$USER_{it} = \gamma_0 + \gamma_1 COMP_{it} + \gamma_2 STOCK_{it} + \gamma_3 DEBT_{it} + \gamma_4 RD_{it} + \gamma_5 FS_{it} + \gamma_6 IDR_{it} + \gamma_7 IND_{it} + \gamma_8 QR_{it} + \gamma_9 CYCLE_{it} + \gamma_{10} DIV_YIELD_{it} + \gamma_{11} ST_DEBT_{it} + \nu_{it} \ldots.(3)$$

where:

USER is a binary variable and coded 1 if the firm uses financial instruments, 0 otherwise. We use probit regression on the full sample of 1,834 firm-years to estimate equation (3). Following Greene (2004), γ and W are denoted as the coefficient vector and the explanatory variable vector in the financial instruments user model respectively. And let $\hat{\gamma}$ be the estimate of γ. Then, the inverse Mills ratio is defined as: $\mathbf{MILLS} = \phi(\hat{\gamma}'\mathbf{W}) / \Phi(\hat{\gamma}'\mathbf{W})$ if **USER** variable equals 1 and $\mathbf{MILLS} = \phi(\hat{\gamma}'\mathbf{W}) / [\Phi(\hat{\gamma}'\mathbf{W}) - 1]$ if **USER** variable equals 0, where: $\phi(\bullet)$ and $\Phi(\bullet)$ are denoted as the standard normal probability density function and the standard normal cumulative distribution function, respectively. We include MILLS as an additional control variable to correct for potential self-selection bias in the empirical equation.

Common Explanatory Variables for both $|\mathbf{DIC}|$ *and* $\mathbf{DER}$ *Equations*

Cash compensations for managers are increased with the firm's performance such as profit. The interest conflicts exist between managers and shareholders conditional on maximizing managers' self-interests. Managers might want to increase their cash compensations by increasing earnings myopically. It is expected that cash compensations (COMP) will be positively associated with the pivotal variables, i.e., $|\mathbf{DIC}|$ and $\mathbf{DER}$. COMP is measured as the directors', supervisors', and CEOs' salaries and bonuses, scaled by lagged total assets. It is also found that managers have incentives to increase earnings to raise their values brought from ownership. Thus, we expect managers' stock holdings to be associated with $|\mathbf{DIC}|$ and $\mathbf{DER}$. Stock holdings (STOCK) are measured as the sum of percentages of the stock ownerships owned by directors, supervisors, and CEO. In addition, managers may avoid violating the debt covenants based on accounting performance. DeFond & Jiambalvo (1994) provide evidence that managers tend to increase earnings when the leverage is raised. We use debt-to-assets ratio (DEBT), defined as total liabilities divided by total assets, to proxy for leverage risk. It is expected that DEBT will be associated with our two pivotal variables, i.e.,

$|\mathbf{DIC}|$ and $\mathbf{DER}$.

Baber et al. (1991) point out when pre-R&D earnings are low, managers may strategically prune away investment in R&D expenditures. It suggests that R&D intensity will be positively associated with $|\mathbf{DIC}|$ and $\mathbf{DER}$. Thus, we incorporate R&D intensity into empirical models to capture the relationship between R&D intensity and two explained variables. R&D intensity is defined as the ratio of R&D expense to equity market value. Moreover, Jorion (1990) documents that foreign sale is positively associated with the absolute value of exposure to foreign exchange rate risk. Since exports sale is an important revenue for listed firms in Taiwan, we expect firms with international diversification have more opportunity to manage earnings by way of $|\mathbf{DIC}|$ and $\mathbf{DER}$. We thus use ratio of foreign sales to total sales (FS) to measure firms' business diversification to capture the possible influences of diversification on $|\mathbf{DIC}|$ and $\mathbf{DER}$. Wang & Kao (2005) reveal that interest-rate risk is positive associated with $|\mathbf{DIC}|$ and $\mathbf{DER}$. Following Wang & Kao (2005), we use the absolute value of the difference between interest revenues and interest expenses scaled by net sales (IDR) to measure interest-rate risk and expect IDR will be positive with $|\mathbf{DIC}|$ and $\mathbf{DER}$. Naturally, the percentage of firms belonging to electronic industries is 64.89% in our empirical data, thus, an electronic industry dummy variable (IND) is used to control for the industry characteristics. IND is coded 1 if the sample firm belongs to electronic industry and 0 otherwise.

Control Variables for the Discretionary Accruals Model

Previous studies document that when pre-management earnings are low, managers might myopically increase earnings to maintain the common dividend payout levels. Dividend payout ratio (DPR) is defined as the ratio of cash dividends to earnings per share before discretionary accruals. In addition, managers in industries with more accounting flexibility are likely to manage accruals to a greater extent (Barton, 2001). The present study follows Barton (2001) and uses the root mean squared error of equation (4) as a proxy for industry accounting flexibility (FLEX). It is expected that FLEX will be positively associated with the magnitude of discretionary accruals.

The literature related to discretionary accruals are based on the *maintained hypothesis*; however, Dechow et al. (1995) point out that the modified Jones model will overstate the magnitude of discretionary accruals for firms with extreme operating cash flows. The absolute value of operating cash flows scaled by lagged total assets (|OCF|) is used to control for the potentially measurement error. If ROA of a firm is high, the manager is less likely to myopically increase earnings (Bowen et al., 1995). ROA in this paper is measured as the ratio of net income before interest and depreciation net of tax to average total assets. The relation between ROA and $|\mathbf{DIC}|$ is predicted to be negative. In the view of economics of regulation, large firms tend to manage earnings to avoid the monitors from capital market regulator and the government. DeFond & Park (1997) provides evidence on the positive relation between firm size and the magnitude of discretionary accruals. The natural logarithm of net sales, denoted as SIZE, is the proxy of firm size in this paper.

Control Variables to Financial Instruments Usage Regulated by SFAS No.34

Firms with large current assets face less financial distress (Nance et al. 1993). Froot et al. (1993) also indicate that the liquidation of assets is negatively associated with the use of derivatives. Therefore, quick ratio (QR), defined as the ratio of quick assets to current liabilities, is used to be a proxy for a firm's liquidation. Firms with long cash conversion cycles are more likely to benefit from hedging because their cash flows are exposed to volatility in market prices (Barton 2001). Cash cycle (CYCLE) is measured as the average collection days of accounts receivables, net of the average payment days of accounts payables, plus average days of inventory sell-out. CYCLE variable is predicted to be positively related with **DER** . In addition, Barton (2001) documents that large expected dividend yield increases the firm's cash need, managers tend to hedge against the volatility in cash flows. Hence, we expect that dividend yield (DIV_YIELD), measured as the ratio of cash dividends to market value of common stocks, will be positively correlated with **DER** . Finally, firms with shorter debt maturity are more likely to use interest rate swaps to hedge risk exposure, thus, a positive correlation between short maturity debts and DER is expected (Barton 2001). Short maturity debts (ST_DEBT) are measured as current liabilities divided by total liabilities.

EMPIRICAL RESULTS

We first present the summary statistics and correlation analyses of related variables in this study. Second, two-stage least squares regression results for the DER and |DIC| simultaneous equations are presented.

Descriptive Statistics

Table 3 reports the descriptive statistics for the related variables in this study. The average absolute discretionary accruals (|DIC|) is 0.073, which is statistically significant at 1% level. The average financial instruments usage (DER) is 0.019. The average ratio of cash compensations (COMP) is 0.9%. It indicates that managers receive relative moderate cash compensations in the sample. The average ownership of managers (STOCK) is 23.8% (median is 20.9%) and show the ownership structures of firms in Taiwan are characterized by a higher degree of concentration. The average ratio of leverage and average R&D intensity are approximately 0.37 and 0.024, respectively. More than half of revenues come from foreign sales documents that international business activities play an important role in the revenues structure in our sample. The average ratio of interest difference is 0.014. The mean of FLEX is 0.017 and documents that there is little difference in the flexibility of GAAP in different industries. The average ROA of the sample is approximate 6%. The average cash conversion cycle is about 101 days. The average dividend yield is 3%. Finally, the average SH_DEBT is 0.758 which reveals half of the total liabilities are short maturity debts in the sample of this study.

Table 3: Descriptive Statistics of Related Variables (n=1,834).

Variables	Mean	Standard Deviation	First Quartile	Median	Third Quartile
|DIC|	0.073	0.094	0.023	0.049	0.093
DER	0.019	0.092	-0.005	0.000	0.020
COMP	0.009	0.008	0.003	0.007	0.012

STOCK	0.238	0.135	0.139	0.209	0.303
DEBT	0.371	0.175	0.236	0.364	0.486
RD	0.024	0.035	0.003	0.013	0.031
FS	0.530	0.441	0.164	0.571	0.822
IDR	0.014	0.086	0.002	0.005	0.010
IND	0.650	0.477	0.000	1.000	1.000
DPR	0.399	0.420	0.000	0.410	0.663
FLEX	0.017	0.008	0.017	0.017	0.020
|OCF|	0.108	0.110	0.039	0.080	0.152
ROA	0.059	0.103	0.017	0.064	0.115
SIZE	14.819	1.496	13.868	14.682	15.645
QR	1.824	2.142	0.822	1.261	2.083
CYCLE	101.101	135.138	45.063	79.659	122.678
DIV_YIELD	0.030	0.028	0.000	0.025	0.051
ST_DEBT	0.754	0.210	0.619	0.801	0.934

Legends:
|DIC|=discretionary accruals. DER=financial instruments usage regulated by SFAS No.34. COMP=cash compensations for managers scaled by lagged total assets. STOCK=the ownership owned by managers. DEBT=the ratio of total liabilities to total assets. RD=the ratio of R&D expenditures to market value of common equity. FS=the ratio of net foreign sales to net sales. IDR=the absolute value of difference between interest revenues and interest expenses scaled by net sales. IND=1 if the sample firm belongs to electronic industry, and 0 otherwise. DPR=the ratio of cash dividends to earnings net of discretionary accruals per share. FLEX=the root mean squared error of equation (4). |OCF|=the absolute value of operating cash flows scaled by lagged assets. ROA=the ratio of net income before interest and depreciation net of tax to average total assets. SIZE=nature log of net sales. QR=the ratio of quick assets to current liabilities. CYCLE=the average collection days of accounts receivables, net of the payment days of accounts payables, plus average days of inventory sell-out. DIV_YIELD=the ratio of cash dividends for common stock to market value of common equity. ST_DEBT=current liabilities scaled by total liabilities.

Correlation Analysis

According to the study of Barton (2001), earnings is the sum of cash flows and accruals, thus, the variance of earnings (σ_E^2) is a function of the variance of cash flows (σ_C^2), the variance of accruals (σ_A^2), and the correlation coefficient of cash flows and accruals (ρ_{CA}). In other words, the equation $\sigma_E^2 = \sigma_C^2 + \sigma_A^2 + 2\rho_{CA}\sigma_C\sigma_A$ will be hold. Therefore, it is reasonable to observe that managers smooth earnings volatility by adjusting cash flows volatility, accruals volatility, and/or the correlation between cash flows and accruals. However, when the myopic earnings increase motivation replaces the possible earnings smoothing behavior by managers, it is expected to find distinct relationship between financial instruments usage and discretionary accruals, which is different with those observed in Barton (2001) and Wang & Kao (2005). The present study first follows the procedure suggested by Barton (2001) and correlates the earnings volatility with $|\mathbf{DIC}|$ and $\mathbf{DER}$ variables to provide preliminary comparison evidences. We use sample firm's quarterly data to calculate the coefficient of variation (CV) to measure volatility. Panel A in Table 4 presents the descriptive statistics for the coefficient of variation for earnings, operating cash flow, and total accruals. The average coefficients of variation of earnings, operating cash flow, and total accruals are 2.660, 4.926, and 8.948, respectively. It is found that total accruals are more volatile than operating cash flows and earnings.

Panel B in Table 4 presents the correlations between **DER** (|**DIC**|) and the coefficient of variation (CV) of related variables. It documents that **DER** is insignificantly negative-associated with the volatilities of cash flows and accruals. But the rank correlations between **DER** and the volatilities of earnings is 0.058 which is statistically significant at 5% level. This result is inconsistent with the finding of Barton (2001) and does not support the **DER** smoothing earnings volatility conjectures. The correlation between |**DIC**| and volatilities of earnings is 0.005 which is positive but not statistically significant. Operating cash flows and total accruals are both negatively associated with |**DIC**| and again are inconsistent with the finding of Barton (2001). Overall, the fact that financial instruments usage regulated by SFAS No.34 (i.e., DER) and discretionary accruals (i.e., |DIC|) are positively associated with the volatility of earnings suggests that managers do not use both financial instruments and discretionary accruals to smooth earnings volatility. Thus, the conclusion that the usage of financial instruments can smooth earnings volatility, which is suggested by Barton (2001), is called for further examinations.

Although the untabulated Pearson/Spearman correlation matrix for the related variables in equations reveal most of the independent variables are correlated with others, the variance inflation factors (VIF) of the explanatory variables (unreported) in the regressions are less than 10 and do not suggest severe multi-collinearity problems (Neter et al., 1989).

Table 4: Rank Correlations between |DIC| and DER and the Coefficient of Variation.

Panel A. Descriptive Statistics for the Coefficient of Variation(n=1,834)

Variables	Mean	Standard deviation	First quartile	Median	Third quartile
Coefficient of variation for the variable: [a]					
Earnings	2.660	18.774	0.305	0.570	1.196
Operating cash flows	4.926	23.029	0.803	1.704	3.704
Total accruals	8.948	46.213	1.239	2.431	5.375
Correlation between operating cash flows and total accruals	-0.857	0.292	-0.993	-0.970	-0.875

Panel B. Correlations between |DIC|, DER and the Coefficient of Variation (n=1,834) [b]

CV of variables	|DIC|	DER
CV of earnings	0.005	0.058**
CV of operating cash flows	-0.025	-0.002
CV of total accruals	-0.053**	-0.005
Correlation between operating cash flows and total accruals	-0.031	-0.007

Legend:

a. The coefficient of variation is the standard deviation of the variable divided by the absolute value of its mean, based on quarterly data for 2006 and 2007.

b. *, **, *** denote significance at the 10%, 5%, and 1% levels respectively, based on two-tailed tests.

Simultaneous Regression Results

From Table 5, the coefficients of DER in Equation (1) and |DIC| in Equation (2) are 3.067 (t=29.28) and 0.256 (t=7.00), respectively, and both positively statistically significant at 1% level. It documents that managers use both financial instruments and discretionary accruals to increase earnings, yet, not to smooth earnings. It is reasonable to conclude that managers

use financial instruments and discretionary accruals as complement tools rather than substitute tools in create firms' net income. Our hypothesis is empirically supported.

The empirical results from common control variables are discussed as follows. The coefficients of COMP variable are -0.501(t=-2.43) and -0.193 (t=-0.67) in the DER and |DIC| models, respectively. It is unexpected to find that COMP is negatively associated with DER and |DIC|. This may be due to the fact that cash compensation in many Taiwanese firms is replaced with stocks or stock options in recent years. The coefficients of STOCK variable are -0.046(t=-4.27) and 0.003 (t=0.21) in the |DIC| and DER models, respectively. The coefficient of STOCK is negative statistically significant associated with |DIC| at 1% level. It implies that the interest conflict between shareholders and the managers holding large shareholdings is not severe and consistent with the argument of Jensen and Meckling (1976). However, in the DER model, the coefficient of STOCK is positive but not statistically significant. The coefficient of DEBT is 0.281(t=24.07), which proxy of leverage risk, is positive statistically significant associated with |DIC|. Consistent with the finding of DeFond & Jiambalvo (1994), this result reveals that the firms with higher leverage are more inclined to manipulate earnings.

Table 5: Regression Results for Simultaneous Equations (n=1,834).

$$|\mathbf{DIC}|_{it} = \alpha_0 + \alpha_1 \mathbf{DER}_{it} + \alpha_2 \mathbf{COMP}_{it} + \alpha_3 \mathbf{STOCK}_{it} + \alpha_4 \mathbf{DEBT}_{it} + \alpha_5 \mathbf{RD}_{it} + \alpha_6 \mathbf{FS}_{it} + \alpha_7 \mathbf{IDR}_{it} + \alpha_8 \mathbf{IND}_{it} + \alpha_9 \mathbf{DPR}_{it} + \alpha_{10} \mathbf{FLEX}_{it} + \alpha_{11} |\mathbf{OCF}|_{it} + \alpha_{12} \mathbf{ROA}_{it} + \alpha_{13} \mathbf{SIZE}_{it} + \alpha_{14} \mathbf{MILLS}_{it} + \zeta_{it} \cdots (1)$$

$$\mathbf{DER}_{it} = \beta_0 + \beta_1 |\mathbf{DIC}|_{it} + \beta_2 \mathbf{COMP}_{it} + \beta_3 \mathbf{STOCK}_{it} + \beta_4 \mathbf{DEBT}_{it} + \beta_5 \mathbf{RD}_{it} + \beta_6 \mathbf{FS}_{it} + \beta_7 \mathbf{IDR}_{it} + \beta_8 \mathbf{IND}_{it} + \beta_9 \mathbf{QR}_{it} + \beta_{10} \mathbf{CYCLE}_{it} + \beta_{11} \mathbf{DIV_YIELD}_{it} + \beta_{12} \mathbf{ST_DEBT}_{it} + \alpha_{13} \mathbf{MILLS}_{it} + \xi_{it} \cdots (2)$$

		|DIC|			DER		
Variables	Expected sign	Coefficients		t-stat.	Coefficients		t-stat.
Constant		-0.059	***	-3.132	0.015		1.043
|DIC|	+				0.256	***	7.000
DER	+	3.067	***	29.284			
COMP	+	-0.501	**	-2.426	-0.193		-0.667
STOCK	+	-0.046	***	-4.269	0.003		0.206
DEBT	+	0.281	***	24.069	-0.054	***	-3.579
RD	+	0.383	***	8.353	-0.116	*	-1.821
FS	+	0.001	***	5.449	-0.0004		-1.345
IDR	+	-0.148	***	-5.509	0.067		1.512
IND	+	-0.050	***	-14.150	0.006		1.170
DPR	+	-0.009	**	-2.442			
FLEX	+	1.631	***	8.382			
|OCF|	+	0.362	***	23.844			
ROA	-	-0.045	***	-2.776			
SIZE	+	-0.003	**	-2.544			
QR	-				0.005	***	4.358
CYCLE	+				-0.00004	**	-2.368
DIV_YIELD	+				0.006		0.071
ST_DEBT	+				0.001		0.130
MILLS	?	-0.004	*	-1.675	-0.001		-0.275

Adjusted R^2	0.61		0.06	
F-statistic	206.22	***	9.85	***

Legends:

1. MILLS is the inverse Mills ratio obtained from Equation (4). Other variables are defined in Table 3.
2. *, **, *** denote the significance on 10%, 5%, and 1% levels respectively, based on two-tailed tests.

The coefficients of RD variable are 0.383(t=8.35) and -0.116(t=-1.82), which statistically significant at 1% and 10% level respectively, in the |DIC| and DER models. The statistically significant positive relation between R&D intensity and discretionary accruals reveals that managers with more growth opportunities tend to manage earnings to prevent underinvestment problems. However, the negative relationship between RD and DER suggests that the usage of financial instruments is decreased for managers with more growth opportunities. It is interesting to find that FS is statistically significant positively related with |DIC|, yet, statistically insignificant negatively related with DER. It implies that managers with higher exchange rate risk increase the use of discretionary accruals. However, a distinct pattern is revealed by the IDR variable empirical findings. The coefficients of IND variable are -0.050(t=-14.150) and 0.006(t=1.170) in the |DIC| and DER models, respectively. The empirical results reveal that the use of discretionary accruals is decreased for firms belonging to electronic industry when comparing with firms in other industries. Nevertheless, managers in electronic industry use slightly more financial instruments. The reason for this result may be attributed to the fact that there is strong demand for cash flow hedge for firms in electronic industry and managers use financial instruments to smooth cash flows volatility, then, decrease the usage of discretionary accruals.

As to the exclusive variables in the |DIC| model, the coefficients of FLEX and |OCF| are 1.631(t=8.38) and 0.362(t=23.84), respectively, which are both positive and statistically significant at 1% level. It reveals that firms with more FLEX and larger magnitude of operation cash flows tend to use discretionary accruals to manipulate earnings. The coefficients of DPR, ROA and SIZE are -0.009(t=-2.44), -0.045 (t=-2.78) and -0.003(t=-2.54), both negative and statistically significant at 5%, 1% and 5% level, respectively. As to the exclusive variables in the DER model, the coefficient of QR variable is 0.005(t=4.36), positive and statistically significant at 1% level. The coefficient of CYCLE variable is -0.00004(t=-2.37), negative and statistically significant at 5% level. The coefficients of DIV_YIELD and ST_DEBT are statistically insignificant.

ROBUSTNESS TEST

The present study implements some diagnostic checks (untabulated) to confirm our initial findings. First, we know that three-stage least squares (3SLS) extend 2SLS and include all equations estimation at the same time. In order to gain confirmatory evidence to support our empirical results, the 3SLS regression is implemented in this study to estimate more efficient coefficients. The result of 3SLS regression reveals that the coefficients of DER in Equation (1) and |DIC| in Equation (2) are 0.689(t=2.74) and 0.079(t=2.15), both positive and statistically significant at 1% and 5% level, respectively. This additional evidence suggests our empirical result is robust to the 3SLS regression examination.

Second, the present study further examines DER and |DIC| models independently by traditional ordinary least squares (OLS) to gain comparing evidence. These further examination results reveal that the coefficients of DER in Equation (1) and |DIC| in Equation (2) are 0.060(t=3.27) and 0.101(t=4.33), again, both positive and statistically significant at 1% level, respectively. The significantly positive relation between DER and |DIC| indicates that the primary results do not topple by separated OLS estimations of Equation (1) and (2).

Third, the present study replaces the discretionary accruals measured from cross-sectional Jones (1991) model by the discretionary accruals measured from cross-sectional modified Jones model. In the 2SLS regressions, the coefficients of DER in Equation (1) and |DIC| in Equation (2) are 3.146(t=30.38) and 0.257(t=7.25), respectively, both positive and statistically significant at 1% level. In the 3SLS regressions, the coefficients of DER in Equation (1) and |DIC| in Equation (2) are 0.796(t=3.55) and 0.085(t=2.18), which are positive and statistically significant at 1% and 5% level in the |DIC| and DER models, respectively. The additional evidence suggests that the positive correlation between DER and |DIC| unlikely results from the misspecification of discretionary accruals.

Finally, in order to gain comparative results with Barton (2001), we further use the stock concept to measure the position of financial instruments held by sample firms. Accordingly, DER variable is redefined as the sum of notional amount of financial assets and financial liabilities regulated by SFAS No.34 scaled by lagged total assets. The 2SLS regression empirical results show that the coefficients of DER and |DIC| are 0.988 (t=13.32) and 0.220(t=4.73), respectively, when discretionary is measured by Jones model. Alternative, the 2SLS regression empirical results report the coefficients of DER and |DIC| are 1.039 (t=13.95) and 0.224(t=4.97), respectively, when discretionary is measured by modified Jones model.

In summary, we obtain supportive evidence on our hypothesis that managers view derivatives and discretionary accruals as partial complement tools in enhancing earnings. The above additional diagnostic checks demonstrate that our empirical results are robust to different estimating methods and specifications of variables.

CONCLUSION

Prior studies document that firms can use derivative instruments to speculate and/or to arbitrage on private information, yet, few studies highlight the risk hedging motive and ignore the important roles of the other two key participants. Adam & Fernando (2006) argue that the active usage of derivatives is thought to add value by alleviating a variety of market imperfections through hedging. Gèczy et al. (2007) also suggest that financial derivatives involve real action which plays an important role in strategically boosting firm's earnings and view speculation as a positive profitability activity. Although Barton (2001) and Wang & Kao (2005) evidence managers appear to trade-off derivatives and discretionary accruals for incentives to smooth earnings. The present study alternatively use the financial instruments usage regulated under SFAS No.34 in Taiwan to examine the hypothetical complement relationship between financial instruments usage and discretionary accruals in enhancing earnings.

The empirical result indicates that financial instruments usage is positive associated with the magnitude of discretionary accruals and supports our complement hypothesis. It suggests that managers use financial instruments and discretionary accruals jointly to increase earnings, contrary to the conclusions of Barton (2001) and Wang & Kao (2005). Our empirical results to some extent evidence the possible potential multi-purposes of financial instruments usage and support the findings of Sapra (2002). These results remain robust to various specification tests.

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G4 – Organizational-management perspectives

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PROCESS IMPROVEMENT OF THE SILICON WAFER LASER DICING FOR FRONT SIDE MEANDERING

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ABSTRACT

This study concentrates only silicon wafer laser dicing. It has the major problem which is meandering. According to the very narrow saw street in silicon wafer, only 15 µm, the saw kerf from laser dicing process exceed into chip circuit that will be the defect. The objective of the research study is to find the optimal settings for silicon wafer laser dicing process in order to achieve the target of 3 µm maximum fluctuation of meandering.

Keywords: meandering; laser dicing; design of experiment; fractional experiment.

INTRODUCTION

Nowadays, competition in the manufacturing industry is increasing in both domestic and international markets. Significant factors that make a manufacturing company competitive in the worldwide market are quality, delivery and cost. It is generally agree that the quality and cost represent an essential factor in business's growth. Therefore, the thought of quality and cost are highly important.

With ongoing miniaturization of IC's the ratio of the functional wafer surface gets lower and lower. The non functional wafer area for the next generation of RFID chips rises up to 30% with smallest conventional saw lane design available. Therefore new chip separation technologies were evaluated to enable a significant reduction of the saw lane width and thus a significant increase of the number of dies per wafer.

Currently, the conventional concept to separate chip is blade dicing, which has saw blade to saw on wafer saw lane. However, the capability of blade dicing is limitation. This method can support at 50 µm saw lane width in minimum. And with mechanical sawing on silicon might lead to generate the chipping or crack on wafer as well.

Therefore, laser dicing machine, the high accuracy and high capability machine used to separate wafer, is applied to improve quality and reducing cost. That's can support the silicon wafer which are 15 µm saw lane width. The concept of laser dicing is laser diode will generate the

pulse to destroy silicon structure and breaking the wafer again after laser pulse. With this concept there is no chip or crack happen compare to blade dicing method. Since this is quite new concept machine so, sometimes the unforeseen problem might be happen.

As mentioned above there are some serious defects happened. Meandering is one of the most critical. The characteristic of defect is look like wavy kerf. That's still acceptable if the maximum fluctuation is not over than 3 µm. In fact we faced about 4 to 5 µm. Since the new type of wafer, the saw lane width was decreased to 15 µm to gain more and more chip in one wafer. That's mean this kind of defect can be destroyed of whole wafer. And those defect silicon wafers will be scraped.

As a conclusion, the meandering was a major problem in laser dicing process. The fault tree analysis is applied to find the potential root cause of meandering. Next, the Design of Experiment (DOE) is applied to reduce this kind of defect. After the experiments are conducted, the best setting is selected. Next, the confirmation experiment are conducted in order to confirm the settings that the maximum fluctuation us not over 3 µm.

BACKGROUND

In the past silicon wafers have been diced by using blade saw. This method is called blade dicing method. Kumagai et al. (2007) the blade dicing process causes undesirable mechanical vibrations and stress in the wafer which make damage in the wafer consisting of cracks, chippings, etc. When the dicing processing speed increases or wafer thickness decreases, the defects increase as well. However, the semiconductor wafers are becoming thinner and thinner in advanced manufacturing. Moreover, the processing speed is important characteristics for the productivity. In order to solve blade dicing problems, laser dicing methods have been developed (Hermanns, 2005). Stealth dicing method is one kind of laser dicing methods (Fukuyo et al, 2005). The laser beam is focused into the interior of the work wafer as well as the laser processing only occurs inside the wafer. The coolant and washing water are not necessary at all for this stealth dicing method since it does not cause any frictional heat and debris. The stealth dicing method has three advantages as follows (Kumagai et al., 2007).

1) High-speed dicing for thinner wafers without any chipping.

2) No debris contaminants that are caused by blade dicing or laser ablation;

3) Completely dry process.

METHODOLOGY

In order to search for the optimal setting of the laser dicing process, the following steps are performed:

1. Determine the potential factors affected to the fluctuation of meandering by using fault tree analysis.
2. Conduct the screening experiment with 3 replications to eliminate the factors which is not affected the fluctuation of meandering.
3. Conduct the following experiment to determine the best settings which give the smallest maximum fluctuation of meandering.
4. Conduct the confirmation experiment in order to confirm the settings that the maximum fluctuation us not over 3 µm.

RESULTS

By brainstorming with process and manufacturing engineers, four major areas 1) product 2) machine 3) process and 4) materials, are used as the focused area for fault tree development.

The fault tree analysis for meandering is shown in figure 1.

Figure 1: Fault tree analysis for meandering.

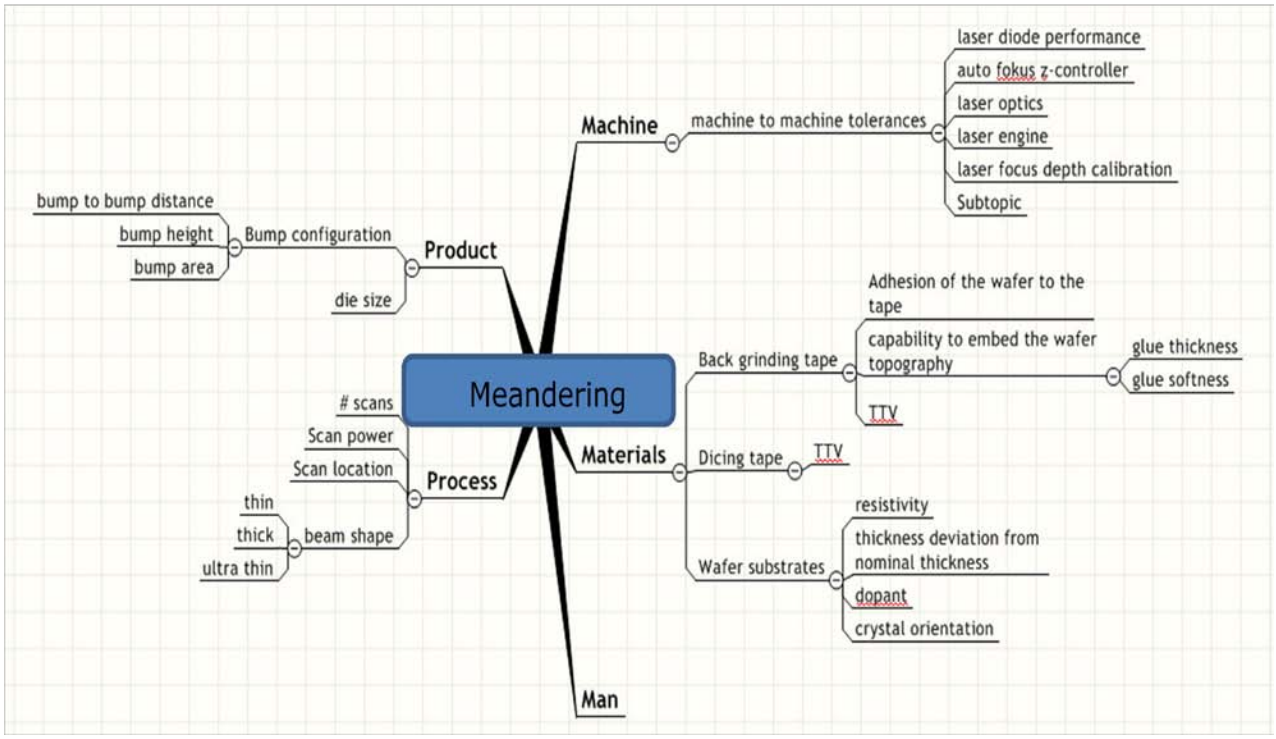

Figure 1: Fault tree analysis of meandering.

For the product, there is only one product type for experiment and they are from the single source. For machine, machine was calibrated to make sure that it is ready for running. For

materials, there is only one type of backgrind tape, dicing tape and wafer substrates. Therefore, the potential factors affected to the fluctuation of meandering are from process which are scanning height (factor A), scan power 1 (factor B), scan power 2 (factor C), beam shape (factor D) and scanning speed (factor E). These factors are considered at two levels each. The levels for all factors are shown in table 1.

Table 1: Factors and Levels of 2^5 factorial experiment.

Factors	Level	
	Low	High
scanning height (A)	10,9	16,3
scan power 1 (B)	0.12 Watt	0.36 Watt
scan power 2 (C)	0.18 Watt	0.54 Watt
beam shape (D)	Ultrathin	Thick
scanning speed (E)	100 mm/s	300 mm/s

The results are shown in table 2.

Table 2: Results of 2^5 factorial experiment with 3 replications.

Scanning Height (A)	Scan Power 1 (B)	Scan Power 2 (C)	Beam Shape (D)	Scanning Speed (E)	REP I	REP II	REP III	Average
10,9	0.12	0.18	Ultrathin	100	3.42	3.11	3.43	3.32
16,3	0.12	0.18	Ultrathin	100	3.54	3.03	3.5	3.36
10,9	0.36	0.18	Ultrathin	100	2.67	3.43	2.83	2.98
16,3	0.36	0.18	Ultrathin	100	3.02	3.23	2.8	3.02
10,9	0.12	0.54	Ultrathin	100	2.45	3.76	2.4	2.87
16,3	0.12	0.54	Ultrathin	100	2.98	3.01	2.34	2.78
10,9	0.36	0.54	Ultrathin	100	2.04	1.54	1.45	1.68
16,3	0.36	0.54	Ultrathin	100	1.52	2.2	1.75	1.82
10,9	0.12	0.18	Thick	100	6.2	4.4	5.67	5.42
16,3	0.12	0.18	Thick	100	6.34	5.87	5.34	5.85
10,9	0.36	0.18	Thick	100	4.65	5.67	4.63	4.98
16,3	0.36	0.18	Thick	100	5.52	5.21	5.22	5.32
10,9	0.12	0.54	Thick	100	5	4.53	5.05	4.86
16,3	0.12	0.54	Thick	100	4.67	4.56	4.63	4.62
10,9	0.36	0.54	Thick	100	4.01	4.12	4.24	4.12
16,3	0.36	0.54	Thick	100	4.03	3.96	4.17	4.05
10,9	0.12	0.18	Ultrathin	300	3.21	3.21	3.59	3.34

16,3	0.12	0.18	Ultrathin	300	3.48	3.49	3.21	3.39
10,9	0.36	0.18	Ultrathin	300	2.66	2.93	2.95	2.85
16,3	0.36	0.18	Ultrathin	300	3.25	2.81	2.94	3
10,9	0.12	0.54	Ultrathin	300	2.67	2.99	2.89	2.85
16,3	0.12	0.54	Ultrathin	300	2.74	2.85	2.64	2.74
10,9	0.36	0.54	Ultrathin	300	1.94	1.85	1.99	1.93
16,3	0.36	0.54	Ultrathin	300	2.35	2.02	2	2.12
10,9	0.12	0.18	Thick	300	5.39	5.69	4.61	5.23
16,3	0.12	0.18	Thick	300	5.17	5.39	5.17	5.24
10,9	0.36	0.18	Thick	300	5.04	5.08	4.92	5.01
16,3	0.36	0.18	Thick	300	4.73	4.78	5.49	4.98
10,9	0.12	0.54	Thick	300	5.19	5	5.18	5.12
16,3	0.12	0.54	Thick	300	4.61	5.02	5.29	4.97
10,9	0.36	0.54	Thick	300	4.02	4.51	3.84	4.12
16,3	0.36	0.54	Thick	300	3.93	3.53	4.58	4.01

The Analysis of Variance is applied to analyze the results as shown in table 3.

Table 3: ANOVA table of 2^5 factorial experiment with 3 replications.

Source of Variation	Degree of Freedom	Sequential Sum Square	Adjusted Sum Square	Mean Square	F	P-value
A	1	0.0360	0.0360	0.0360	0.31	0.578
B	1	9.2877	9.2877	9.2877	80.22	0.000
C	1	14.9468	14.9468	14.9468	129.10	0.000
D	1	107.8232	107.8232	107.8232	931.29	0.000
E	1	0.0011	0.0011	0.0011	0.01	0.924
A*B	1	0.0504	0.0504	0.0504	0.44	0.511
A*C	1	0.2035	0.2035	0.2035	1.76	0.189
A*D	1	0.0054	0.0054	0.0054	0.05	0.830
A*E	1	0.0273	0.0273	0.0273	0.24	0.628
B*C	1	1.4652	1.4652	1.4652	12.66	0.001
B*D	1	0.0294	0.0294	0.0294	0.25	0.616
B*E	1	0.0063	0.0063	0.0063	0.05	0.816
C*D	1	0.0077	0.0077	0.0077	0.07	0.797
C*E	1	0.4760	0.4760	0.4760	4.11	0.046
D*E	1	0.0782	0.0782	0.0782	0.68	0.414
Error	80	9.2622	0.1158			
Total	95	143.7066				

R-Sq(adj) = 92.35%

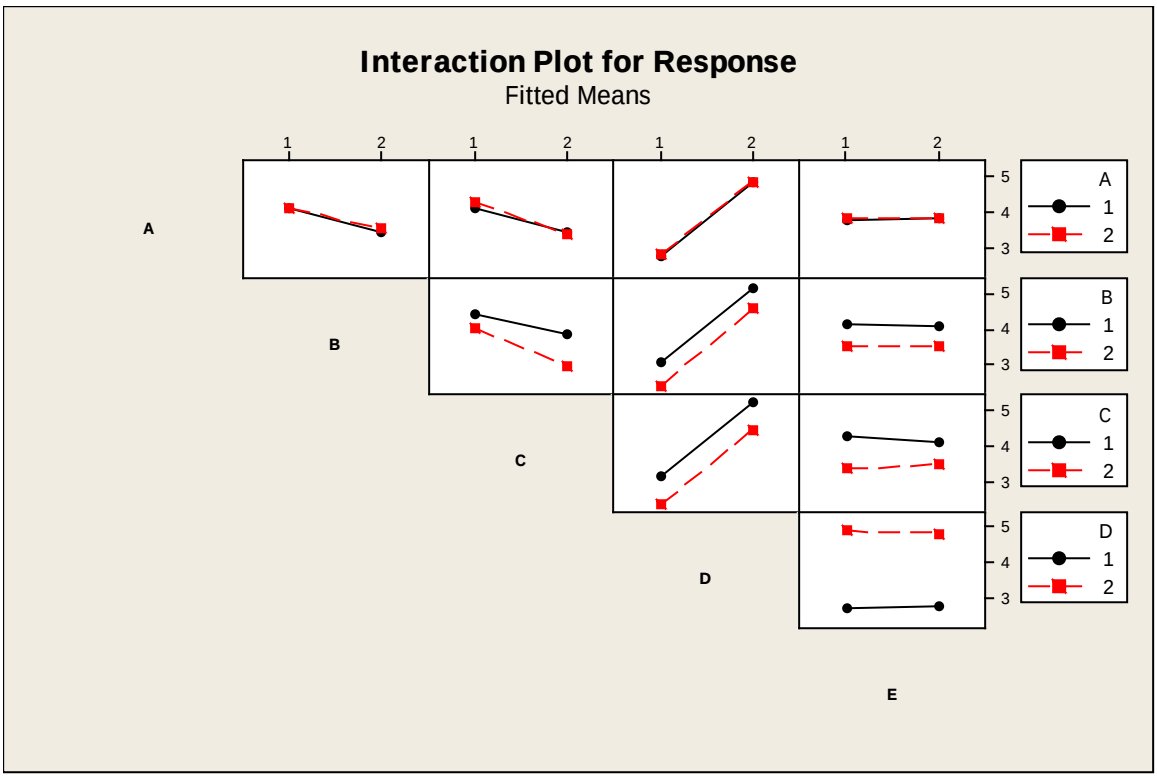

Figure 2: Interaction plot for response 2^5 factorial experiment.

According to table 3, the factors which affect to fluctuation of meandering is factor B,C, D and interaction of factor B and C by using 0.01 significance level. For the following experiment, factor B and C is conducted with four levels. However, factor D is conducted with two levels. According to figure 2, interaction plot of factor D with factor A, B, C and E at level 1 (ultrathin) give the smaller responses than level 2 (thick). Therefore, the following experiment is conducted with two levels which are ultrathin and thin for factor D. Next the $4^2.2^1$ factorial experiment with 5 replications is conducted. The levels for each factor are shown in table 4.

Table 4: Factors and Levels of $4^2.2^1$ factorial experiment with 5 replications.

Factors	Level			
	1	2	3	4
scan power 1 (B)	0.12	0.24	0.36	0.48
scan power 2 (C)	0.18	0.36	0.54	0.72
beam shape (D)	Ultrathin	Thin		

For the factors which are not affected to the fluctuation of meandering, they are fixed at the appropriate value. Scanning height (factor A) is fixed at the middle value of 10,9 and 16,3 which is 13,6. Scanning speed (factor E) is fixed at 300 mm/s because this is the maximum value of scanning speed which gives the highest productivity. The results are shown in table 5.

Table 5: Results of $4^2.2^1$ factorial experiment with 5 replications.

Scanning Height (A)	Scan Power 1 (B)	Scan Power 2 (C)	Beam Shape (D)	Scanning Speed (E)	REP I	REP II	REP III	REP IV	REP V	Average
13,6	0.12	0.18	Ultrathin	300	3.42	3.56	2.54	4.02	2.78	3.26
13,6	0.12	0.18	Thin	300	3.96	3.54	3.63	3.42	2.98	3.51
13,6	0.12	0.36	Ultrathin	300	2.87	2.89	3.25	3.02	2.87	2.98
13,6	0.12	0.36	Thin	300	2.86	2.84	2.57	2.89	3.05	2.84
13,6	0.12	0.54	Ultrathin	300	2.59	2.65	2.54	2.36	2.58	2.54
13,6	0.12	0.54	Thin	300	2.56	2.56	2.87	2.69	2.61	2.66
13,6	0.12	0.72	Ultrathin	300	3.56	3.47	3.84	3.15	3.21	3.45
13,6	0.12	0.72	Thin	300	3.45	3.56	3.06	3.52	3.02	3.32
13,6	0.24	0.18	Ultrathin	300	2.89	2.56	2.87	3.02	2.56	2.78
13,6	0.24	0.18	Thin	300	3.21	3.25	3.31	3.36	3.35	3.30
13,6	0.24	0.36	Ultrathin	300	1.98	2.03	2.56	2.21	1.87	2.13
13,6	0.24	0.36	Thin	300	2.13	2.19	2.13	2.20	1.98	2.13
13,6	0.24	0.54	Ultrathin	300	1.54	1.52	1.23	1.54	1.26	1.42
13,6	0.24	0.54	Thin	300	2.09	1.99	2.23	2.27	2.38	2.19
13,6	0.24	0.72	Ultrathin	300	2.25	1.54	1.25	1.54	1.32	1.58
13,6	0.24	0.72	Thin	300	2.68	2.54	2.62	2.61	2.54	2.60
13,6	0.36	0.18	Ultrathin	300	2.54	2.25	2.31	1.26	2.25	2.12
13,6	0.36	0.18	Thin	300	2.62	2.56	2.41	2.81	2.23	2.53
13,6	0.36	0.36	Ultrathin	300	2.30	2.24	2.25	2.31	2.25	2.27
13,6	0.36	0.36	Thin	300	2.32	2.26	2.19	2.31	2.35	2.29
13,6	0.36	0.54	Ultrathin	300	1.68	1.84	1.98	1.84	1.20	1.71
13,6	0.36	0.54	Thin	300	2.01	2.06	2.21	2.25	2.21	2.15
13,6	0.36	0.72	Ultrathin	300	2.54	2.38	2.56	2.41	2.56	2.49
13,6	0.36	0.72	Thin	300	1.53	1.85	2.15	2.12	2.03	1.94
13,6	0.48	0.18	Ultrathin	300	2.87	2.89	2.56	3.01	2.54	2.77
13,6	0.48	0.18	Thin	300	2.56	2.25	2.74	2.89	2.45	2.58
13,6	0.48	0.36	Ultrathin	300	2.56	2.84	2.63	2.85	2.41	2.66
13,6	0.48	0.36	Thin	300	2.56	2.65	2.58	2.23	2.55	2.51
13,6	0.48	0.54	Ultrathin	300	2.57	2.56	2.54	2.56	2.58	2.56
13,6	0.48	0.54	Thin	300	2.47	2.85	3.02	2.56	2.86	2.75
13,6	0.48	0.72	Ultrathin	300	3.25	3.25	3.03	3.06	2.98	3.11
13,6	0.48	0.72	Thin	300	3.25	3.46	3.54	3.56	3.24	3.41

The Analysis of Variance is applied to analyze the results as shown in table 6.

Table 6: ANOVA table of $4^2.2^1$ factorial experiment with 5 replications.

Source of Variation	Degree of Freedom	Sequential Sum Square	Adjusted Sum Square	Adjusted Mean Square	F	P-value
B	3	21.6533	21.6533	7.2178	100.25	0.000
C	3	8.8777	8.8777	2.9592	41.10	0.000
D	1	1.2691	1.2691	1.2691	17.63	0.000
B*C	9	8.0395	8.0395	0.8933	12.41	0.000
B*D	3	2.1260	2.1260	0.7087	9.84	0.000
C*D	3	1.0527	1.0527	0.3509	4.87	0.003
Error	137	9.8638	9.8638	0.0720		
Total	159	52.8820	52.8820			

R-Sq(adj) =78.35%

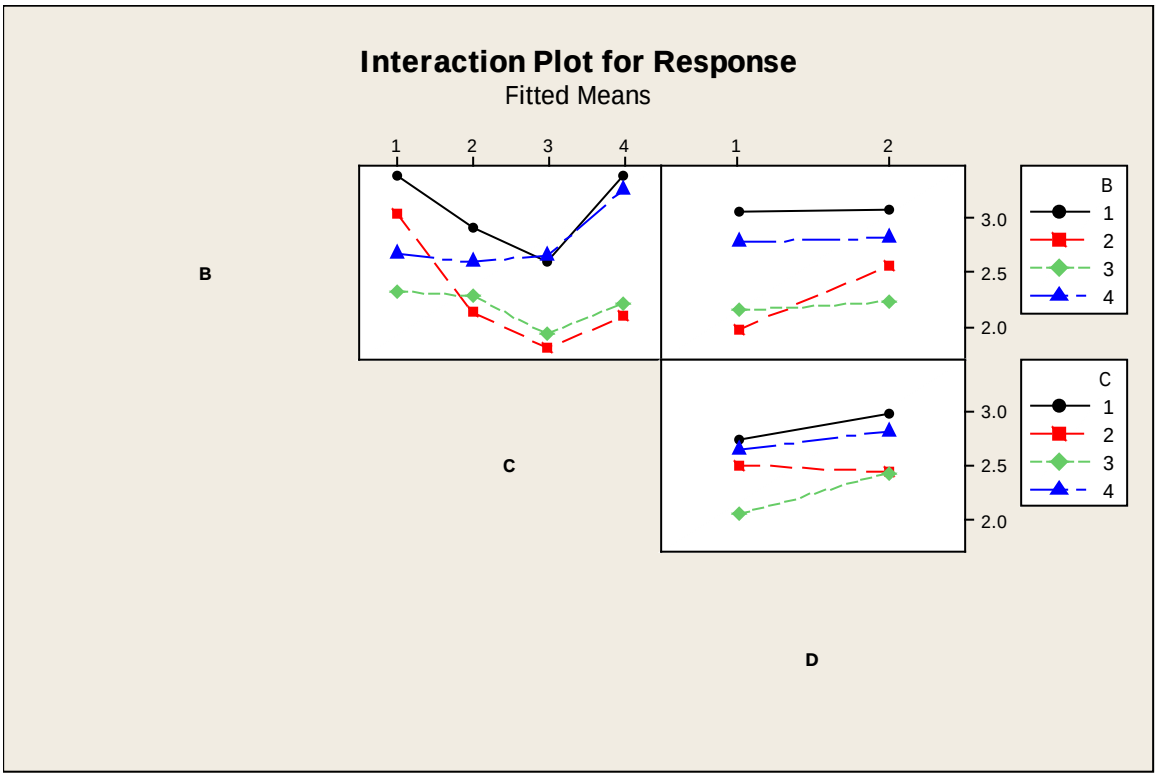

Figure 3: Interaction plot for response of $4^2.2^1$ factorial experiment.

According to table 6, the factors which affect to fluctuation of meandering is factor B, C, D, BC interaction, BD interaction and CD interaction by using 0.01 significance level. According to figure 3, the best settings which give the smallest maximum fluctuation of meandering are level 2 (0.24 Watt) of factor B, level 3 (0.54 Watt) of factor C and level 1 (ultrathin) of factor D.

Next, the confirmation experiment is conducted in order to confirm the settings that the maximum fluctuation us not exceed 3 µm. The results are shown in table 7.

Table 7: The results of the confirmation experiment with 40 replications.

Wafer no.	Response	Wafer no.	Response	Wafer no.	Response	Wafer no.	Response
1	0.93	11	0.77	21	2.79	31	1.66
2	2.40	12	0.90	22	2.37	32	2.48
3	**3.38**	13	1.31	23	2.48	33	0.58
4	1.57	14	0.93	24	1.65	34	0.84
5	1.74	15	2.61	25	0.45	35	1.40
6	2.17	16	2.26	26	2.31	36	1.21
7	1.76	17	0.41	27	0.74	37	0.91
8	1.29	18	2.61	28	1.39	38	0.94
9	0.80	19	2.02	29	1.80	39	0.83
10	1.76	20	0.27	30	0.98	40	2.64

According to table 7, there is only one slice which is shown the maximum fluctuation of meandering exceeds the target. This can be acceptable.

CONCLUSIONS

The factors affected to the fluctuation of meandering are scan power 1, scan power 2 and beam shape. The best setting of scan power 1 is 0.24 Watt, scan power 2 is 0.54 Watt and beam shape is ultrathin. The benefit after implemented the new settings is shown in table 8

Table 8: The benefit after implemented the new settings.

Process	Average loading	% reject	wafer amount	cost/wafer (k.euro)	Reject cost	Saving
Past parameter	520	4.62	24	14	336	45.83%
New parameter	520	2.5	13	14	182	

After implemented new parameters to shop floor, specimen silicon wafers from 40 slices. There is 1 from 40 slices which shown defects from meandering. That is 2.5 %. Typically, average loading is 520 wafers per month, average rejected wafers per month are 24 slices that is 4.62%. Comparing to defect rate of the new parameter, the numbers of rejected wafers are 2.5% or 13 wafer slices per month by using the same average loading per month. Wafer cost is totally 14,000 euro per slice. Therefore, it can be save cost up to 45.83%.

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TQM PRACTICES IN PUBLIC SERVICE ORGANIZATIONS CASE OF HEALTHCARE AND ACADEMIC LIBRARIES

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ABSTRACT

Purpose *–This study aims to discuss the evolution, principles, and stages of total quality management (TQM) in health care and academic libraries. It points out the discrepancies between these two types of service organizations by elaborating their present strengths, weaknesses, possibilities and threats while making TQM practices in their organizations. It also makes a comparison that how case organizations think about the definition of quality and TQM philosophy along with its applicability within public sector.*

Design/methodology/approach *–The study can be categorized as qualitative research. The data is collected from semi structural interviews of the informants and the concerning documents, which consist of strategy, policy papers and audit reports of the case organizations. Altogether there are four case organizations, two of these are from health care and two from academic libraries. Furthermore, data is analyzed with the help of content analysis.*

Findings *–It is obvious from the results that the most vital issues in TQM practices are its comprehensiveness, and its application in such a way which is appropriate for the organization, with a logical way of operation and the participation of management and personnel. TQM is seen as quite applicable to the service sector however, it requires being reconciled with strategic management initiatives.*

Managerial implications *–Training, guidance, teamwork, involvement and learning are imperative for achieving a continuous improvement culture and are vital elements when adopting TQM. Managers should learn from the experience of TQM implementers by studying expected challenges and pitfalls. They should also pay more attention to the crucial role of all stakeholders in the TQM implementation.*

Originality/value *–The study could be quite valuable from a strategic perspective in providing guidelines to build up a proper plan for TQM practices more promptly. The paper also manages to shed light on TQM practices of public service organizations by comparing their current approaches to quality.*

Keywords: TQM, Quality management systems, Service organization, Healthcare, Academic libraries

INTRODUCTION

In the past TQM used to be implemented in the manufacturing sector, but now it has also been widely applied in service organizations and the public sector (Fryer et al., 2007) e.g. higher education (Venkatraman, 2007) health care, libraries and information sectors (Moghaddan et al., 2008). All kinds of organizations in the private as well as the public sector are looking to be customer-oriented organizations to carry on their operations in a globally competitive environment. Therefore to compete as customer-oriented organizations it is necessary to offer quality products and services to their customers. Subsequently, TQM is such/specifically a philosophy that provides the tools and the direction to improve the quality of their products and services.

However, TQM implementation in manufacturing firms is not considered a novel and multifaceted strategy, but TQM implementation and practice particularly in public service organizations like healthcare and academic libraries are really quite a recent and composite undertaking. The introduction of the TQM term in health care is well established, but there is still lack of such a supporting framework that can make it easier for newcomers to follow the boulevard. Likewise, academic libraries have always been committed to provide high quality services to its subscribers. Although previously, consuming more resources, buying more books, and moving to larger premises were considered as improving quality, this approach is not valid today. One of the good solutions to improving quality is to provide the right information to the right user at the right time. This requires a thorough change in the approach – an approach based on user requirements and user satisfaction. It is believed that this can be achieved by implementing TQM. Thus, TQM approach is slowly achieving popularity in today's libraries. Regardless of this current recognition, many service organizations seem to be perplexed by their TQM practices. They give the impression that TQM approach is being properly practiced but the real scenario is quite different in most of these service organizations.
Therefore, the objective of this research is to study which kinds of TQM practices there are in public sector services, whether they are applying a fully-fledged TQM approach or only some parts of the TQM are being employed? More specifically, this research proceeds to examine the implementation of TQM in the public service organizations in the attempts to:

- present an overview of TQM initiatives in service organizations
- identify the level of understanding and knowledge about TQM in health care and academic libraries
- make comparisons of TQM practices in both health care and academic libraries

To accomplish the objective mentioned above and to achieve sub goals of the study, the paper will analyze the distinctiveness of the TQM practices in each target organization. First, it will carry on by providing an up to date literature review of the associated terms individually with more emphasis on quality, TQM and its applicability in service organizations. Second, it will elaborate on the methodological approach which has been employed during this study and a description of all target organizations. Third, it will illustrate the results along with discussion and managerial implications. Finally, it draws some conclusions based on the present results and discussions in light of previous literature. It also includes an appendix that portraits an overview of TQM practices and approaches of all case organizations.

DEFINITIONS

Service Quality

Quality is concerned with fulfilling the needs, wants and expectations of the valued customers. One of the key and stable definitions may be that, 'quality is suitability for purpose'. Quality is also defined as 'satisfying customer's requirements' or 'fitness for purpose' (Ghobadian et al., 1994). However, it is complex to define service quality rather than the quality of goods. Service quality can be defines as an attitude of the consumer relating to the results from comparisons between expectations of service with his perceptions of actual performance (Grönroos, 2007). The quality of services executed can only be appraised during or after consumption (Audhesh et al., 2005). The more composite and personal the service, the more detective effort customers will perform (Berry et al., 2006). The primary source of value creation for a service quality is performance by the service provider. It is often the small things that influence a customer's overall perception of service quality, be it the tangibility associated with the service or the behavior or technical performance by the service provider (Kumar et al., 2010).

Service Quality Dimensions

The most commonly stated set of service quality was offered by Zeithaml et al. (1990), who using factor analysis, condensed the dimensions of service quality into five categories:

1. Tangibles (facilities, equipment and appearance of staff);
2. Reliability (ability to perform the promised service dependably and accurately);
3. Responsiveness (willingness to help customers and provide prompt service);
4. Assurance (knowledge and courtesy of staff and their ability to convey trust and confidence);
5. Empathy (caring, individualized attention the organization provides to its customers).

Total Quality Management

According to British Standard BS 7850, TQM is defined as management philosophy and company practices that endeavor to strap up the human and material resources of an organization in the most efficient way to accomplish the organizational objectives. In general, the overall scope of quality, total quality and TQM can be classified as follows (Kanji):

Quality: – is to satisfy customer's requirement persistently
Total Quality: – is to achieve quality at low cost
Total Quality Management: – is to obtain total quality by involving everyone's daily commitment.

According to Vouzas and Psychogios (2007) there are two substantial aspects of TQM that can be identified; the 'hard' side and the 'soft' side. The hard (or technical) side refers to management tools and practices, while the soft (or philosophical) is associated with

management concepts and principles. The hard aspects of TQM consist of clear and well documented methods while the soft aspects compose its whole theory, combining its background and philosophical elements. It is argued that TQM has to evolve. Four stages can be identified in the evolution of TQM:

- Inspection-based System
- System of Quality Control
- Quality Assurance
- Total Quality Management

Quality Management initiated with a simple Inspection-based system, where a product was compared with a product standard by a team of inspectors. First revolutionary charge – System of Quality Control came along with World War II. At that time quality was achieved through control systems, product testing and documentation control. In the Quality Assurance stage, there was a change from product quality to systems quality. Typical of this stage were quality manuals, quality planning and advanced document control. Quality assurance is prevention-based. The fourth stage of development was TQM. A clear and unambiguous vision, few interdepartmental barriers, staff training, excellent customer relations, emphasis on continuous improvement, and quality of the company as a whole are typical in a TQM environment.

Over time the definitions of quality management have been widened to incorporate the wellbeing of society, the environment and future generations. A large part of the development of quality concept and quality management has taken place without much consideration of what quality management really is or should be. It has been claimed, that quality management should focus on customers and their satisfaction and not concentrate on stakeholders and interest parties who are affected by the products and processes (Klefsjö et al., 2008), but on the other hand TQM is in many researches said to be implemented with the help of quality awards, which are considered as excellence models (Bou-Lusar et al., 2008; Vernero et al., 2007).

TQM can be described as the development of an organizational culture, which is defined by, and supports, the constants attainment of customer satisfaction through an integrated system of techniques and tools. TQM is a way of managing to improve the effectiveness, efficiency, flexibility, and competitiveness of a business as a whole. There are eight most common principles in the TQM: leadership and management, strategic planning, focus on customer, focus on employees, focus on suppliers, focus on material resources, process management and performance results (Rad, 2006).

Total Quality Management in Healthcare

In exceedingly competitive healthcare environments, hospitals similar to all other public or private organizations and institutions, are confronted with the stipulation of measuring both their financial (costs, revenues, profitability) and non financial performance (quality of their services), in order to improve their functions and increase their competitiveness (Chaniotakis and Lymperopoulos, 2009). Performance measurement is not an easy task in health services, where a wide range of stakeholders are involved. Lim and Tang (2000) argue

that customer based determinants and perceptions of service quality play an important role in hospitals. Hence, Wisniewski and Wisniewski (2005) revealed that service quality from the patients' perspective should be consistently monitored and assessed. Silvestro (2005) proposes the development of a tool for measuring the gap between patients' priorities and their perceptions and the match between the patient and management perspective.

Ovretveit (2001) has found seven components in integrated quality development in hospitals, which is an application of total quality management in a hospital. The components are based on longitudinal empirical research in European hospitals. The components are as follows:

1. Four coordinated organization-wide programs to develop professionals' competencies, managers' competencies, organization and processes, and a new role for patients;
2. Three-dimensional definition of quality (patient, professional and management quality);
3. Patient pathway and process development;
4. Quality data gathering;
5. Team quality projects;
6. Patient focused system development; and
7. Creating 'soulful spirals' and preventing 'soulless spirals'.

These seven components aim to combine effective established professional quality assurance methods with newer quality improvement methods, simultaneously by improving patient, professional and management quality, and describing and developing the system of care experienced by the patient in a soulful way.

Conceptualization of Critical Dimensions of TQM in Hospitals

Considering the relevance of TQM in health care, an instrument that identifies the operating elements of TQM in hospitals from the viewpoint of the health-care service providers is developed and validated in the present study. The following critical factors of provider-perceived TQM in hospitals have been identified in this paper (Duggirala et al., 2008):

1- Top management commitment and leadership
2- Human resource management in the hospital
- Selection
- Training
- Employee involvement

3- Process management
- Ease of access to the hospital, and ease of admission processes and procedures
- Administrative services
- Processes: administrative and clinical
- Exit
- Clinical outcomes of medical care

4- Hospital facilities and infrastructure
5- Patient focus
6- Employee focus

7- Measurement of hospital performance
8- Hospital information system
9- Errors, safety and risk management
10- Service culture
11- Continuous improvement
12- Benchmarking
13- Union influence
14- Governance and social responsibility

According to Bassand et al. (2007) TQM in healthcare is a relative concept that requires comparison either with the performances of others or with the standards. The measurement of quality needs to be relevant for both service providers and patients, and also the process of care should be measured. There should be regional and/or national programs to measure performance indicators systematically and provide feedback to individual hospitals.

Total Quality Management in Academic Libraries

The mission of academic libraries is to collect and store scientific publications and register, analyze and organize them in a way, that researchers and students can use them. The quality of the academic library is depended mostly on how well a library can support the members of a academic community to work successfully. On the other hand the quality of a university depends partly on the quality of library operations, because high quality research requires wide and updated collections with efficient services. Service is the key value of academic libraries (Sinikara 2007). The services of an academic library could be classified into four groups, in the same way as in marketing literature. First are 'cash cow-services', which are widely used and require little investments, like book lending services. The second are 'star-services', with a high relative market share operating in a high growth market, like the provision of e-content. The third group is 'problem children' which have not achieved dominant position, but have potential to move in this direction, like Really Simple Syndication (RSS) in libraries. The fourth group is 'dog services' for which there is a low need and level of effectiveness, like physical collections of printed abstracts and indexes (Walton 2007).

Quality management in academic libraries can be defined as all of the processes, activities and measures that contribute to the management of the quality of the products, service or other outputs from the organization. There is tension between externally-focused quality assurance and internally-focused quality enhancement and a big challenge for the public sector management is to combine these. Quality assurance is more focused on output standards and measured performance, while quality enhancement is more focused on internal processes as well as the assessment of these. The consequences of quality assurance are funding, accreditations, achievement of quality marks and branding. The consequence of the quality enhancement is quality service delivery. While implementing quality management, a library has to take into consideration the sector (e.g. higher education or local authorities), organization (e.g. university or local authorities), division or strategic business unit, library and information service (e.g. academic or public library), and functions or departments and projects (e.g. new building or new services) (Rowley 2005).

The university libraries in Finland are open for everyone, which is not the case in every European country. The libraries are valuable not only for education and research at the University, but also for the society (Sinikara 2006).

However, due to the nature of the services provided, academic libraries encompass additional complexity to the implementation of any quality management system. The libraries are embedded in larger organizations, they have a high level of engagement with users, they have a wide range of stakeholders, they form complex co-operations with many partners, they increasingly deliver services electronically and they are affected by the public sector services policies (Kostagiolas & Kitsiou, 2008; Rowley, 2005). Table 1 below provides an overview of previously selected related studies to TQM implementation in academic libraries.

Table 1: Previous studies.

Kostagiolas & Kitsiou, 2008	**Purpose:** It aims to empirically assess the current issues and the perceptions for quality management systems implementation in Greek academic libraries.
	Design/methodology/Approach: A qualitative survey based on the development of a questionnaire for semi-structured interviews with the directors of Greek academic libraries.
	Results: An interest for ISO 9000:2000/ISO 9001:2000 has been observed in academic libraries in Greece.
Rowley, 2005	**Purpose:** To review the quality, performance management and impact assessment regimes that currently impact on public and academic libraries in the UK by exploring the challenges for managers in finding their path through this quality maze.
	Design/methodology/Approach: An opinion piece that offers some conceptual frameworks, based on an analysis of literature, practice and web sites gathered over many years' investigation and observation. The tension between externally-focused quality assurance and internally-focused quality enhancement is taken as a point of departure.
	Results: A review of the approaches for collecting customer evaluations of service quality, enhancing quality and performance illustrates the complexity associated with accommodating agendas arising from different contexts, and the competing notions of quality that are embedded in these different approaches.
Kauar et al., 2006	**Purpose:** To describe the steps in attaining the ISO 9001:2000 quality management system certification at the University of Malaya Library.
	Design/methodology/Approach: Case study in four university libraries by including the description of planning, implementation and maintenance of the quality management system along with continual improvement efforts to provide quality service.
	Results: The move towards a quality management system within quality standard requirements, such as the MS ISO 9001:2000 proved challenging to obtaining the management commitment and the reorganization of services. Customer feedback becomes the focus of on-going planning to fulfill customer requirements. A quality management system has brought about informed decision making and increased customer satisfaction.
Dadzie, 2004	**Purpose:** The research examines the possibilities, challenges and constraints faced by top management in a bid to introduce total quality as a management tool to enhance the services provided to the university community.
	Design/methodology/Approach: Case study in one university library. Qualitative study made by using interviews, which were analyzed with help of content analysis.
	Results: The librarians were quite committed to their jobs. The major hindrance to the execution of their strategies and policies has been that of financial resources.
Wang, 2006	**Purpose:** To provide retrospective overview of TQM in the context of library services
	Design/methodology/Approach: Conceptual study/ literature review
	Results: The process of implementing TQM in libraries involves a conceptual change in library professionals and a cultural transformation in the organizational operations. Teamwork is important for successful implementation of TQM. Every step of the process

	depends upon the constant support of the top management.
Moghaddam & Moballeghi, 2008	**Purpose:** To present an overview of TQM in the library and information sectors
	Design/methodology/Approach: Literature review focusing on TQM implementation in the library and information sectors.
	Results: TQM philosophy is increasingly being applied in the service sector, including libraries.
Chim, 2007	**Purpose:** To trace the development and implementation of the quality assurance system and its continuous review process.
	Design/methodology/Approach: Descriptive case study
	Results: To set up a successful QA system requires commitment of both staff and management, and customer focus which means understanding and educating the customers and reacting to customer feedback.
Juntunen et al., 2005	**Purpose:** To present the process of creating quality management system of the Kuopio University Library (Finland).
	Design/methodology/Approach: Case study with some survey-based material
	Results: Quality management can be used as a tool for leadership within the Library, improving the Library's processes and marketing.
Saarti & Balague, 2009	**Purpose:** To benchmark ISO 9001:2000 quality management based systems in Spanish, and in Finish Universities.
	Design/methodology/Approach: Case study in which two libraries' approach to build their quality management system is compared.
	Results: The ISO 9001:2000 guides institutions to develop their quality management systems and it has helped them to develop their services and analyze how they have succeeded in this task.

METHODOLOGY

Despite being a qualitative study, a contingency approach is used in this paper. This is because the approach offers a good way to consider what kind of situational factors should be taken into consideration while implementing a quality management system; but at the same time the theory should be developed in order to consider the level of human actors and not only the organization level (Donaldson, 1996). This study is qualitative also because of the study subject, quality management subject that is a vague subject, given that the term quality has many dimensions (Garvin, 1988) and a hospital is a complex organization with multiple goals (Kast & Rosenzweig, 1970).

A qualitative approach allows a researcher to deal with complexity, context and persona and a multitude of factors and fuzzy phenomena. For example, holistic case studies are applicable in these kinds of situations (Gummesson 2006, 167). Qualitative methods are also very suitable for studies concerning organizational change, because they allow the detailed analysis of the change and by using the qualitative methods we can assess how (what processes are involved) and why (in terms of circumstances and stakeholders) the change has occurred (Cassell & Symon, 1994- 5). However this research process consists of the following steps applied from the study of Lukka (2003):

1. Find a practically relevant problem which also has potential for theoretical contribution.
    - This study also aims to find out which kind of TQM practices there are in public services, and from the theoretical viewpoint it is a question of how to take into consideration all situational factors and special characteristics of a

public service organization when applying quality management which is said to be universalistic.

2. Examine the potential long-term research co-operation with the target organization(s).
3. Obtain deep understanding of the topic area both practically and theoretically.
    - During this study we tried to develop one of the organizations also in practice by building a process measurement system into the heart unit of the hospital.
4. Innovate a solution idea and develop a problem solving construction, which also has potential for theoretical contribution.
    - Because of the universalistic tradition of quality management, a situational quality management model is constructed.
5. Implement a solution and test how it works.
    - A weak market test is made by showing the results to the informants of the each target organization.
6. Ponder the scope of applicability of the solution.
    - The model is constructed in such a way that it could be used in building quality systems in the other public service organizations.
7. Identify and analyze the theoretical construction.
    - The nature of the quality management is considered in the continuum of universalistic theory vs. situational approach to quality management
    - The major types of potential theoretical contributions are the novel construction itself as well as applying and developing the existing theoretical knowledge about quality management features emerging in this case.

The study material consists of semi structural interviews of the informants, audit reports, strategies and other documents available. All the material is analyzed with the help of content analysis. Some previous studies, which have used the same approach, are for example Kunkel & Westerling (2006). Interview made from the following informants:

- Central Hospital of the Vaasa Hospital District (CHV); general manager, manager doctor, quality manager, manager of the heart unit, politician
- Central Hospital of the Keski-Pohjanmaa Hospital District (CHK); general manager, manager doctor, quality manager, manager of the heart unit and worker (group interview), politician
- Kuopio University Library (KUL); quality manager, manager of the library, service manager
- Helsinki University Library (HUL); administrative managers (group interview), manager of the library, quality manager of the student library

The content analysis can be defined as any methodological measurement applied to text (or other symbolic materials) for social science purposes (Duriau et al., 2007). Content analyzes are most successful when they focus on facts that are constituted in language, in the uses of particular texts which the content analysts are analyzing. Such linguistically constituted facts can be divided into four classes: attributions, social relationships, public behaviors and institutional realities. Attributions are concepts, attitudes, beliefs, intentions, emotions, mental states and cognitive processes which ultimately manifest themselves in the verbal attributes of behavior. They are not observable as such. Institutional realities, like the government, are constructions that rely heavily on language. See the exact description of

the content analysis of the study in appendix I and II. Data was collected with the following three sources:

Target Organizations

Altogether there are four target organizations. Two of them are regional hospitals and in both hospitals managers of the units are chosen for examples of sub-units of hospitals because of their supposed quality management experiences. Two libraries are also included which are attached to two different academic universities. Below is a short overview of each exploring their strengths, weaknesses, possibilities and threats regarding TQM practices.

Central Hospital of the Vaasa Hospital District, (CHV)

The Central Hospital of the Vaasa has an administrative role in the Vaasa Hospital District, which consists of three hospitals. The District is owned by 23 municipalities and it is a bilingual organization (both Swedish and Finnish speaking personnel, customers, and owners). The number of the personnel in the year 2006 was 1997, which consisted of nursing staff (1060), physicians (183), research staff (240), and maintenance staff (109). Services are offered for 166,000 inhabitants in the area of the municipalities (SHQuality, 2007). This Hospital District is one of the 20 Finnish hospital districts.

Table 2: Strengths, weaknesses, possibilities and threats concerning TQM.

Strengths	**Weaknesses**
• Enough know-how • A tradition of systematic working • It is easy to learn new theories and models • Well educated personnel • Ethical background • Language of the SHQS is suitable for the health care industry • Much experience of development work • Commitment towards TQM (nursing staff) • Sufficient human resources • Planning of strategies, security policy and risk management (*) • Customer focus(*) • Meeting practices (*) • Human resources management practices, like taking care of well-being of the personnel, recruitment • Benchmarking (*) • Quality management is getting better (*)	• There is insufficient know-how concerning quality work • Traditionally every patient and diagnosis are considered as unique cases without any point of view of production (no production management or sizing) • Multidimensionality of health care, lack of standardized products, rapidly increasing amount of knowledge, which makes it hard to handle the situation and to see the totality • A big organization • Everything must be communicated in Swedish and in Finnish communication • Lack of commitment of physicians and other personnel • There are only a few quality systems in primary health care in this region • Modeling and measurement of processes in hospital and unit levels (*) • Goals and measures of operation and levels and goals should be defined (*) • Part of planning practices (*)

Possibilities	Threats
• Changes in the operation environment force to improve the organization • Changes in the structure of municipalities and services can help hospitals to improve their operations • All the social- and health care units use the same kind of (quality) system and thus it is possible to create a unitary system • To find the process owner for the social and health care services across the organization boundaries • Top management of the central hospital is committed to quality work • Functionality of communication among the special fields	• Border lines between professions • The aim has been to offer almost everything to essentially everybody for free. This leads to a continuous gap between the needs and possibilities of the whole public administration and falls heavily on health care. • Operation environment is changing and resources are needed to follow-up the changes. Maintenance of a quality system requires work on an almost daily basis. • Lack of resources • Cooperation between hospital districts and outpatient care: there is no motivation to improve quality in every place. • More and more specialized health care leads to a situation in which the patient's viewpoint disappears and totality becomes vague

(*) = audit report (SHQuality 2007)

According to the quality policy and strategy, good quality in CHV is defined as service processes which are from the customer's or patient's point of view, high level, available, efficient and economic, and during which the well-being of the personnel and expectations of the stakeholders are taken into consideration (Vaasa Hospital District, 2007). In the strategy there is a decision to establish a quality system for the hospital (Vaasa Hospital District, 2003). In the heart unit of the CHV (8.10.2004) there is a quality manual which is made according to ISO 9001:2000 quality management standard. However, the hospital is still using the SHQS quality system (SHQuality, 2007).

Central Hospital of the Keski-Pohjanmaa Hospital District (CHK)

The Keski-Pohjanmaa Central Hosital has an administrative role in the Keski-Pohjanmaa Hospital District. The District is owned by 13 municipalities and it is a bilingual organization (both Swedish and Finnish speaking personnel, customers, and owners) (Keski-Pohjanmaa hospital District 19.11.2007). The number of the personnel in the year 2006 was 1143 and in the year 2007 it was 1164 (Keski-Pohjanmaa hospital District 2007).

Table 3: Strengths, weaknesses, possibilities and threats concerning TQM.

Strengths	Weaknesses
• Electronic appointment in the laboratory • Citizen's acceptance • Networking with educational institutions • Long traditions of SHQS since the year 1996 • Qualified and committed internal audit group • Positive attitude of the personnel towards development (**) • Small size of the organization (flexibility) • Big volumes and clear procedures of operations	• Funding system and attitudes concerning it • Appointment problems • Lack of commitment • Quality management is not applied on daily basis • No full-time development and quality manager • Small size of the organization • It is difficult to change (bureaucracy, trade-unions, etc.) • Complicated organization • Lack of physicians • No consideration about the totality of the social-

• Commitment of the personnel (*) • Customer focus (*) • Cost awareness (*) • Regional cooperation (*) • Commitment to values (*) • good job satisfaction survey (*)	and health care services • Lack of quality policy (*) • Information systems and knowledge management (*) • risk management (*) • process measurement (*)
Possibilities	**Threats**
• Integrated clinical pathways can become more flexible and efficient while the organization is growing • Quality management may encompass the whole social and health care services	• Belief in extremely big organizations • Recruitment of competent personnel fails • Municipalities don't understand SHQS • Cure is improved on an economic basis instead of the need of patients • Prioritization of the health care • Quality management is applied only partially and the totality is forgotten

(*) = audit report (SHQuality, 2006), (**) = both audit report (SHQuality, 2006) and interviews

In the strategic plan of the hospital, high service quality was mentioned as one of the key values of the hospital. The service quality is based on hearing the needs of the customer and patient, high-quality services, effectiveness, and taking care of knowledge, readiness of operation and facilities of operation (Keski-Pohjanmaa Hospital District, 19.11.2007).

Helsinki University Library (HUL)

Table 4: Strengths, weaknesses, possibilities and threats concerning TQM.

Strengths	**Weaknesses**
• Size of the organization • Commitment towards TQM (**) • Comprehensiveness of the quality management system (**) • Balanced management • Networking inside the organization • Critical thinking • Traditions of overall evaluations • Knowledge • Clear quality assurance operations (*) • Utilization of intranet (*) • Management tools for quality assurance (*) • Utilization of customer feedback in the student library (*)	• Size of the organization • Multifold decision making procedure • Disconnectedness of HRM • Different kinds of resources in the units of the library • There is no material concerning TQM practices in English • Measurement and evaluation (*) • Relationship between support services (like the library), research and education should be developed further for quality assurance (*)
Possibilities	**Threats**
• Internationalization • Benchmarking between the university libraries in the future national structural development • Becoming an improved expert- and service organization with the help of organizational changes and personnel development	• Internationalization • Efficiency is emphasized more and more increasingly • New Universities Act • Structural development • Co-operation between libraries and organization may not work anymore

(*) = audit report (Vuorio et al 2008), both interviews and audit report (Vuorio et al 2008)

The library institution of the University of Helsinki comprises of two large entities until the year 2010: the national Library of Finland and the University of Helsinki Libraries. The student library is one of the libraries in the city center campus. There has been a quality

system since the year 2005 and different kinds of evaluations from the beginning of the 1990´s (Sinikara 2006).

Kuopio University Library (KUL)

Table 5: Strengths, weaknesses, possibilities and threats concerning TQM.

Strengths	**Weaknesses**
• Commitment towards TQM • Providing resources to quality work • Documentation • Co-operation inside the university • The university has developed its quality system in a systematic way based on ISO 9001 quality management system (*) • Good cooperation between quality manager and staff correspondent for quality of the units at the university (*) • Intranet used effectively for quality management (*) • Students' participation in quality work	• Too much documentation • Intranet must be developed • Deficiencies of the intranet • Difficulties in measurement/evaluation at the time when quality system was established, there were four other big projects going on (this is becoming a strength) • Measurement systems should be improved: both measurement and performance indicators (*)
Possibilities	**Threats**
• Benchmarking • They can get savings with help, or develop confidential relationships by merging the universities (Kuopio and Joensuu)	• Eminent decisions may be made too hastily which are considered impossible by other organizations • The cooperation inside the university may disappear

There are 35 staff members in the UKL (Saarti & Balaqué 2009), which is much less than in Helsinki. According to the Research Library Statistics in 2007 there are more recourses (personnel, financial recourses etc.) at the University of Helsinki Library per parent organization than at the University Library of Kuopio. At the Kuopio ththe uey have made more investments on electronic publications than University of Helsinki, which is the biggest university in the Finland (KOTA database 26.4.2010).

FINDINGS

The development of a quality system is the most adopted initiative in all the case organizations. The least adopted TQM initiative is the application of statistical process control. This can be explained by the respondents' lack of knowledge about the exact control methods used by the Quality Improvement departments or, because some hospitals lack the financial resources and expertise to implement these statistical process control methods.

According to the interviews the most important issues in TQM practices are comprehensiveness, a systematic way of operation, the participation of management and personnel, high quality cure processes, reporting and reacting, the implementation of high-level goals (ethics and values), focus on development as well as measurement and goal levels. TQM is seen as quite applicable or very applicable to (a) hospitals and libraries but there are several issues, which foster the implementation of TQM. Language used in the implementation should be familiar and suitable to the target organizations, and unfamiliar

language should not be used by force. SHQS is an example of translating the language of TQM into a language familiar to the healthcare industry. This requires it to be accommodated to healthcare.

In all the case organizations, they claimed that there is no TQM but simultaneously ISO quality standard is implemented there. TQM is usually seen as a method for practicing quality. However, TQM is not applied in every single part of the organization – except maybe in Kuopio Library. In every organization they applied TQM in a way that is typical to the industry: in hospitals they used SHQS and in university libraries they used quality assurance recommended by the Finnish Higher Education Evaluation Council. In the heart unit of the Vaasa Central Hospital and The University of Kuopio, they also applied ISO quality management standard. Furthermore, the heart unit were evaluated by medical experts. In Kuopio they used ISO standard, because it was seen as more suitable for international associations.

It is visible that everybody is talking about quality assurance instead of quality management or TQM. The most important issue in TQM is the totality, participation, continuous improvement and organizational learning process. It was seen as quite easy or very easy to apply in university settings. The context of the university must be taken into consideration and only tools/techniques suitable to the organization should be used. According to the audit reports of the universities, there are problems in measuring quality management at their libraries. In the interviews most problems were seen in the measurement processes of the TQM in such organizations.

An organization should take care of its strengths, get rid of their weaknesses, utilize the possibilities and avoid threats. Cooperation between different organizations was seen as a possibility in every case organization. Commitment of at least part of the staff was seen as strength and measurement of processes was a weakness in every case. Hospitals were more worried about resources than libraries and both libraries considered disappear of co-operation as a threat. Situational factors in operation environment were seen in many different ways: size of an organization was seen as a strength and weakness, like internationalization at the University of Helsinki Library.

DISCUSSION AND IMPLICATIONS

TQM is considered to be a generic management model that is applicable to every organization, but on the other hand it is also suggested that the operation environment of an organization should be taken into consideration while implementing quality management. It is crucial to persuade quality as early as possible, preferably at the initial stage of organizational operations. Organizational structure modification supports the success of TQM which must always be considered. Leadership and top management support are keys to TQM implementation and practice. Upper management must always conduct continuous improvement activities with the consensus of all employees. They should also make use of selective application of TQM tools and techniques by appraising their suitability with the organization. There must also be sufficient financial resources available for TQM initiatives.

Training, tutoring, teamwork and staff involvement are important for achieving a continuous improvement culture and are vital elements when adopting TQM. This claim is supported by Fung's (1998) study which showed that the learning team approach assists in accomplishing an educational organization and attains TQM. It is noted from the findings that most of the staff members from case organizations are not familiar with the approach of TQM, so providing appropriate training for employees and support from top management are considered vital success factors by most researchers (Ennis & Harrington, 1999). This result is consistent with the results of Rad (2005) concerning the key success factors for TQM implementation.

Successful TQM implementation requires top management commitment, employee involvement and empowerment, customer focus and continuous improvement, training for TQM throughout the organization and increased communication. Furthermore, there is a need for patience and tolerance as it is a time-consuming process and it is not easy to change an organization. An increased focus on the area of organizational change related to TQM is also needed. To conclude, the successful TQM implementation requires a thorough understanding of critical success factors, barriers to achieving these factors, and managerial tools and techniques to overcome these barriers along with continuous organizational learning. The barriers of the implementation of the TQM are resistance to change and people's attitudes, problems in finding funding and time for training, while maintaining current services in the library. It is also difficult to make a change in organizational structures, yet TQM requires institutions to restructure themselves (Moghaddam & Mogalleghi 2006) and be ready to learn each and every thing that occurs over the passage of time.

Finally, the results of research argue that TQM initiative implementation may seem to be an easy task, but this is a very illusory deliberation. The dilemma is not only how to implement the agenda, but how to make it work effectively and efficiently. Managers as well as quality policy makers should pay more attention to the vital role of all stakeholders in the TQM implementation and success stages. A non-implementer of the TQM philosophy should learn about the expected challenges and pitfalls from the experiences of TQM implementers.

CONCLUSION

From the assessment of present practices of TQM in public healthcare units and academic libraries, it is apparent that TQM or narrowly associated approaches are not just a 'fashion of the day'. Case organizations are practicing quality in the form of quality assurance, continuous improvement, user satisfaction, etc., if not exactly in the appearance of TQM. The resolutions of TQM may fluctuate from service organization to organization, as each is unique in itself. The certainty of the modern service organization indicates that quality improvement is indispensable not only for survival, but for facing major changes and growth required for organizations of the present and of the future.

It is concluded from the research findings, that there is a considerable divergence regarding the development of a quality system and TQM practices in case service organizations. This advocates the need for enhanced communication between all level managers in order to

attain an environment of quality improvement and a TQM system that requires the full integration between each stakeholder of the organization. It also argues that changing to a TQM idea requires a new administrative view, a change in the organization structure to eliminate the barriers, and improved communication through information systems with a long-term organizational learning perspective.

Future Research

Future research is vital in appraising the understanding and the critical success factors for TQM based on the customers' point of view. Also, further studies need to be undertaken concerning the detailed impact of organizational culture and structure, top management support and employee training and involvement of TQM implementation in service organizations.

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Appendix I. Description of the analysis of the study material

The study material consists of qualitative data gathered from interviews and documents concerning the target organizations. Interviews referred frequently to the documents during the interviews, and therefore the study material is analyzed separately. The study material was gathered in the following ways:

Target organization	Helsinki University Library	Kuopio University Library	Keski-pohjanmaa Central Hospital	Vaasa Central Hospital
Interviews Type	Semi-structured	Semi-structured	Semi-structured	Semi-structured
Documents	Strategy, audit report (Vuorio et al 2008)	Strategy, audit report	Strategy, audit report	Strategy, audit report, quality policy

Interviews took from 30 minutes to 2 hours. Every interviewee was presented with questions beforehand so they were prepared. They also had key documents in the interview with them or they remembered them so well, that they could refer to them (for example quality policy, strategy and audit reports if available).

All the interviews were recorded and afterwards the recording material was transcripted. The transcripts of the recordings were analyzed with the help of content analysis. The results of the analysis were interpreted with the help of previous literature. After this analysis, a weak market test was made with the key informants in the beginning of the year 2010. Part of the study material had already been tested in two separate single case studies, which helped in the analysis of this study.

Appendix II. Comparison of the cases

Definition of the quality and approach to TQM

	HUL	KUL	CHK	CHV
Definition of quality	Operation appropriate to situation and high level results	Best possible results, products and operation attainable with the available resources. Support services' (like library services) are of appropriate size to support key processes (teaching and research) and are lean, open and flexible. These should be appropriate, free from defects with short lead times and support good enough facilities and equipment. The quality of a library consists of a combination of management and professional services. It can be viewed as the customers´ subjective view of the quality of service, as well as the pedagogic point of view, defined as the customer learning to find information and using the library independently	Best possible cures in a cost-effective and appropriate way including the availability of the service. Small amount of defects, combination of different kinds of viewpoints, i.e. experience of the patient, technical quality of the cure, management and personnel; all good operations; systematic operations, enough documentation and well-defined regulations	Good available cure based on patients/customers needs, effective and economic service processes, and operations in which the well-being of the personnel and expectations of the stakeholders are taken into consideration. Quality is based on the values of the health care industry. Everybody has a different point of view to the meaning of quality.
Approach to TQM VS strategy *Why quality is needed? *Most important issues in total quality	Quality is based on strategy and strategy is based on quality. Quality must be improved to get better results, which calls for the development of operations and continuous improvement. The most important issues in QM are totality, participation, continuous improvement and learning	QM is part of strategic management, is based on it and very closely connected to it. QM is made for both internal and external reasons. The most important issues in QM are the following: to support strategic management, participation of the personnel, to work with QM and improve results.	QM supports the establishment of a strategy by giving information. There has to be 4-6 key goals in a smaller unit and well thought out meanings to these goals in their operations. The goals in the units have to be concrete and connected to time, resources and economy. QM is needed because of the following reasons: To get an overall view of operation: economy + personnel + process/customers viewpoint. Only operations of good quality are sensible. Operations can't be improved without	Quality system and strategy are closely interconnected. The quality system calls for clear strategic goals and vision. Quality work is based on values, which in turn are included in strategy. QM is needed for the following reasons: - to control totality - to implement values - On the other hand it is a management fad, but it is also needed a) to guarantee cure for customers and to show what kind of working place it is. - low quality work

	processes. The word quality assurance is used instead of quality management		evaluation and documentation. The most important issues in QM are the following: - patient centeredness, communication with personnel, being in the right place at the right time from the operations point of view - to find measures and to develop evaluation - follow-up - Clear management system based on information and documentation generated by quality management	must be avoided - required regulations The most important issues in QM are the following: - comprehensiveness - applying QM in a way which is suitable for the organization - systematic way of operation - participation of management and personnel - high quality cure processes - reporting, reacting - nothing is forgotten (because the SHQS is a type of check list), implementation of high-level goals (ethics and values), finding focus on development, measurement and goal levels

Applicability to the public sector

	HUL	KUL	CHK	CHV
How easy it is to apply in the public sector?	quite easy or very easy	quite easy or very easy	quite easy	quite easy or very easy
Reasons why it could be applicable	Context is taken into consideration; such quality tools/techniques are used, which are suitable to the organization, and the usage is thoroughly thought out		- the existence of an organization depends on quality - if the special characteristics of the context of the public sector are taken into consideration while applying QM, it is well applicable because evaluation is so important.	total quality management – thinking is very applicable to pubic administration, if it is reconciled with health care
Issues which make it difficult to apply QM:	If the context of the university is not taken into consideration		If innovativeness is decreasing because of the ”quality”. If the total situation of a patient with multiple problems is nor taken into consideration.	Organizational structure as a mixture of service and production organization, difficulties in standardization and more dramatic understanding of deficiencies in health care compared to the production of goods.

Total quality management in practice

	HUL	KUL	CHK	CHV
State of art	Quality work is almost institutionalized	Quality work is more like everyday work	Quality work is both every day work as well as a separate project.	Quality work is both every day work (like in the heart unit) and distinct development work.
Practical implications in quality work	The use of manual operation systems, networking and group work	Evaluation, education of personnel and students, and work of self-directed teams	Education and projects in which clinical pathways and service chains are identified and described together with stakeholders efficiency of personnel is increasing patients stay a shorter time in hospital, implementation of SHQS and evaluation	Establishment of quality systems into different units of the hospital is most important. Other implications are process improvement and documentation concerning risks
Quality tools	Different kinds of evaluations, statistics, and work groups.	Documentation (quality manuals etc.), different kinds of evaluations, education and group work methods, ISO 9000, and check lists in customer service.	SHQS and quality tools, which include flow charts and cause-and-effect diagrams	SHQS (includes self-evaluations and audits), ISO quality management standards, and group work methods

The roles of the personnel and management in the TQM

	HUL	KUL	CHK	CHV
The role of personnel	The implementation of change	Commitment and participation Nothing can be done without personnel	To do the work as well as possible, participate in development projects, work as a member of an expert team, consider feedback in an appropriate way and not emotionally	Commitment, good work and know how concerning continuous improvement
The role of management	Commitment To work in the interface of the parent organization, changing environment and personnel.	Commitment, providing resources and to take the lead To motivate and to get personnel to work in self-directed manner	To provide resources, emphasize the importance of quality and work as a role model. To provide information on statistics, and reward appropriately	To motivate personnel, commitment, work as a role model and provide resources

Evaluation and measurement in the organization

	HUL	KUL	CHK	CHV
Measurement and evaluation in general	Evaluations, audits, customer surveys, statistics, and other follow-up´s, check lists	At university level, mainly teaching and research are measured	SHQS, and medical evaluations Because they are made on the side, it is	SHQS (includes self-evaluations and audits), evaluations of authorities, follow-up

		There are 25 indicators, and unit specific indicators	important to consider how much time can be spent on evaluations; what are the benefits compared to the time used on evaluations	of statistics, benchmarking etc.
Measurement of customer satisfaction	surveys are coordinated, other operations are not	different kinds of surveys spontaneous customer feedback is analyzed by the evaluator and results are discussed in the meetings of the workplace	Common surveys; clinic specific evaluations, like questionnaires, calling to patients and feedback boxes; utilization of ICT will come in the future Evaluations must have some kinds of consequences i.e. the possibility to change things	twice annually in a systematic way there are paper surveys and possibilities to give feedback on the internet, follow-up of quality deviations, and reports of a patient representative feedback is discussed in the different units of the hospital
Process measurement	Both qualitative and quantitative measurement, and measurement of effectiveness	customer satisfaction, cost-effectiveness, importance of the service, and quality	delay (time), patient satisfaction, technical quality, economy/costs, personnel, lead time, efficiency, effectiveness, medical evaluation etc., measurement of both diseases and patients' service processes	There should be measurement instruments with many viewpoints and correct amount of measures Measurement should be connected to merit pay Measurement and analysis should be as automatic as possible (electric equipment are needed). Quality of life could be measured The need for both quantitative and qualitative measures
Problems in the utilization of the evaluations and measurements	utilization of the gathered data measurements of effectiveness are difficult, for example the kinds of impacts the library has on learning reliability choosing of the measures systematic operation in measurement and evaluation	It is difficult to find qualitative indicators There are too many indicators There are too few respondents Uncertainty whether measures are reliable.	utilization of information technology is underdeveloped Interpretation of the feedback is difficult More services should be measured; less diagnosis, and there should only be 5-20 measures Finns are not in the habit of complaining (too polite)	all the measures should not be chosen at the hospital level The effectiveness of the units can't be measured and is the right thing being done some things can be changed slowly (for example lack of physicians) and others quickly measurement is not automatic enough and not part of normal operation,

				measures don't measure processes properly (mortality is a measure, but it doesn't happen)

Process improvement

	HUL	KUL	CHK	CHV
Importance of the processes for good quality. How to improve processes?	Processes are important Processes should be improved by modeling them and increasing productivity (more work with less staff).	Processes are important Processes should be improved by: modeling and getting to know the processes, documented instructions, planning the processes for the future for the merger of the university of Kuopio and University of Joensuu, development of measurement and concentrating on the most important issues	Processes are important It is important to increase service oriented development instead of diagnosis centeredness, to get rid of queues and use more information technology. A clinical pathway is a wider concept than a process; there must be compatibility between processes and clinical pathways.	Processes are important Processes should be improved by identifying, describing and measuring them. Very long traditions of some professions make development work difficult and optimizing the work of one group may not guarantee the quality of the whole process. Knowledge of how many services are needed (volume of orders), what capacity and resources this requires, and costs of production. The goals of the hospital are vague: to make patients healthy. The decisions of what is produced and how much are made inside the hospital independently of customers' needs and owners' wants.

AN EMPIRICAL ANALYSIS OF THE RELATION BETWEEN BOARD STRUCTURE AND FIRM VALUE : CASE STUDY OF THAI LISTED COMPANIES IN SET 100

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ABSTRACT

The objective of this study is to analyze the relationship of a firm value with the structure of board members of firms that are listed in Thailand SET 100. The independence variables are board size, percentage of independent director, percentage of financial or accounting expertise in audit committee, independent chairman, CEO duality, and percentage of female directors. The dependent variable is firm value which is estimated by using Tobin's Q. The data used for the analysis are from financial statement between the years 2007 to 2009. There are 87 companies being investigated in this study. The study also excludes financial, insurance, property fund, and banking sectors. The result suggests that the structure of board members of a firm has the relationship with the value of a company and only CEO duality that show the statistical significant.

Keywords : Corporate Governance, Thailand, Firm Value, Tobin's Q, Board Structure

INTRODUCTION

Given the increasing importance of corporate governance in Thailand, many researches have studied the role of corporate governance. Corporate governance consists of the set of processes, customs, policies, laws and institutions affecting the way a corporation is directed, administered or controlled. Corporate Governance also includes the relationships among the many stakeholders involved and the goals for which the corporate is governed. Organization for Economic Co-operation and Development (OECD, 2004) defines corporate governance as the system by which business corporations are directed and controlled. The corporate governance structure specifies the distribution of rights and responsibilities among different participants in the corporation such as, the board, managers, shareholders and other stakeholders, and spells out the rules and procedures for making decisions on

corporate affairs (Kajola, 2008). In conclusion, corporate performance structure comprises internal control, market control, board control, corporate charter, law and regulation

About the Code of Corporate Goverance (2004) in the Thailand Securities and Exchange Commission stated that the Board of Director is responsible for governing the firm through an objective, independent check on its management. Solomon (2004) also Vander Bauwhede & Willekens (2003) stated that there should be accurate and free-flowing information going in and out of the board to promote a healthy, functioning corporate body; more than just assuming responsibility for the financial statements. Fama and Jensen (1983) theorize that the board of directors is the highest internal control mechanism responsible for monitoring the actions of top management.

According to the meaning, principles and empirical research of corporate governance, those illustrate the important of corporate governance to organization. In Thailand, corporate governance is the concentrate area in the Securities and Exchange Commission (SEC) and the Stock Exchange of Thailand (SET), both institutes have disbursed to corporate governance. The SET focuses on internal control in improving its corporate governance of Thai firms, especially on the structure of board of directors (Yammeesri and Herath, 2010).

Many empirical researches provide evidence about the important of including outside directors on the board for purposes of monitoring management in agency problem. The relation between board of director composition and firm value is particularly important to the accounting profession. Fama's (1980) and following research conducted by Fama and Jensen (1983) also stated board composition and board of director's recommendations propose that having higher percentage of outside directors increases the board's effectiveness as a monitor of management. Fama and Jensen (1983) acknowledged that the board toned down the agency problem by acting as advisors to the CEO and executive managers, and to be boundary spanners in expanding the company linkage with the external environment, as well.

According to the limited local studies on this accounting phenomenon also the increased importance of corporate governance in Thailand, this study empirically examines by attempting to assess the role of corporate governance practices, particularly those involving the structure of board of directors, in explanatory the firm value listed in the SET 100, Thailand. This study intent to provide the beneficial results to several stakeholders for bringing these knowledge to improve the feature of corporate governance.

THEORETICAL BACKGROUND AND DEVELOPMENT OF HYPOTHESES

A number of studies based on the relation between the structure of board of director and firm value argued that the structure of board of directors have the relation with the firm

value. Various researches were conducted from a number of methodologies. The conceptual framework of this study is identified in Appendix A.

According to the conceptual framework in appendix A, we define the structure or characteristics of board of directors as independence variable and dependence variable is firm value, which measure by using Tobin's Q. Tobin's Q is calculated in the period that fit with the timeframe. Chung and Pruitt (1994) reported that Tobin's Q measures firm performance under decision making in asset investment.

The independence variables that fit with how to measure the broad structure in this study are as follows: 1. Board Size, 2. Percentage of Independent Directors, 3. Percentage of Financial or Accounting Expertise of Directors in Audit Committee, 4. Independent Chairman, 5. CEO Duality, and 6. Percentage of Female Directors.

As mentioned, several independence variables are defined to examine the relation between board structure and firm value: Case Study of Thai Listed Companies in SET 100, which approaches from literature reviews, can be explained as follows:

1. Board Size (BS): Board size is measured by using total board of director at the end of period. Total board of director will examine whether it can increase the value added of the firm. Pfeffer and Salancik (2003) suggested that the higher the number of directors, the higher financial performance. These findings also matched with what Delton et al. (1999) concluded that the number of the board members has correlations with financial performance which includes accounting measurement and current market value. Moreover, the board members also bring in outside expertise that can improve the effectiveness of a firm. The information about the board members also gets published in the annual report. The hypothesis is proposed as follows:
H1a: The Tobin's Q of firm listed in SET 100 is positively associated with board size.

2. Percentage of Independent Directors (ID): Percentage of independent directors is measured as independent director to the entire number of board of director, it indicates responsibility of directors to make sure that agency problem and the possibility of having nominees may reduce (Beiner et al., 2006; Helland and Sykuta, 2005; Lee and Carlson, 2007). The hypothesis suggests the follow:
H1b: The Tobin's Q of firm listed in SET 100 is positively associated with Percentage of Independent Directors.

3. Percentage of Financial or Accounting Expertise of Directors in Audit Committee (FAE) : Carcello et. Al. (2006) and DeFond et al. (2004) suggest that the proportion between numbers of financial or accounting expertise of directors in audit committee supports the

transparency and the competence of the company. Education background is used to determine the qualification of experts. The hypothesis is as follow:

H1c: The Tobin's Q of firm listed in SET 100 is positively associated with Percentage of Financial or Accounting Expertise of Directors in Audit Committee.

4. Independent Chairman (ID): Independent chairman who has no personal involvement with the company prior joining the board is more likely to protect the benefit of an organization. The chairman position that is held by an independent chairman would also raise the visibility of practicing corporate governance. The information mentioned is also published in the annual report or 56-1 form. The hypothesis is as follow:

H1d: The Tobin's Q of firm listed in SET 100 is positively associated with Independent Chairman.

5. CEO Duality (CD) : Finkelstein and D'Aveni (1994) points out that if CEO has multiple duties and assume double positions such as being a president and a CEO together at the same time, it may encourage him to be able figure out the way to deceive the company. The problem of CEO duality also complements with Mallette and Fowler (1992) about the possibility of passing information to outsiders. Thus, segregation of duties principle is very important for the company. The hypothesis is as follow:

H1e: The Tobin's Q of firm listed in SET 100 is negative associated with CEO Duality.

6. Percentage of Female Directors (FD) : Smith et al. (2006) suggests that multiple genders allow company to increase competitiveness and lead to higher profit. Carter et al. (2003) supports the idea and also conclude that different gender generate mechanism to establish a check and balance system for a company. The following hypothesis is trying to prove the extent to which the proportion of female directors has an effect on the profit and market value of the company. The proportion of female and male director can also be seen in the annual report. The hypothesis is as follow:

H1f: The Tobin's Q of firm listed in SET 100 is positively associated with Percentage of Female Directors.

In this study, the four control variables are defined in order to identify the specific impact of board structure on firm value. The control variables use in this study, have also been included in several researches in the literature.

1. Firm Size (FS): Firm Size is measured as the natural logarithm of book value of total assest. Majummdar (1977) reported that there is a positive relation between firm size and firm performance.

2. Gearing Ratio (GEAR): Gearing Ratio is measured as total liabilities divided by total stockholder's equity. Grossman and Hart (1982) and Jensen (1986) reported that

leverage (measured by total liabilities divided by total assets) shows the positive signal of firm value and management.

3. Percentage of Sale Growth (SG): Percentage of Sale Growth is measured as the total sales of the current year minus total sales of the previous year divided by total sale of previous year. Mak and Kusnadi (2005) stated that sales growth is positively related to firm value.

4. Lagged Return on Assets (ROA): Lagged Return on Assets is measured as operating profit divided by average total assets. By the mean, average total assets are calculated as average of total assets of current year and total assets of previous year.

According to dependence variable, independence variable and control variable, the regression model is defined as follows:

Regression Model :

$$Q_t = \alpha_t + \beta_1 BS_t + \beta_2 ID_t + \beta_3 FAE_t + \beta_4 IC_t + \beta_5 CD_t + \beta_6 FD_t + \beta_7 FS_t + \beta_8 GEAR_t + \beta_9 SG_t + \beta_{10} ROA_{t-1} + \varepsilon_t$$

Where:

Q_t : Tobin's Q in the period of firm *i* in year *t* (Tobin's Q);

α_t : Constant at time *t* (Constant);

β : Coefficient of independence variables at time *t* or time *t-1* (Coefficient);

BS : Total board of director of firm *i* at time *t* (Board Size);

ID : Percentage of independent directors divided by total board of director of firm *i* at time *t* (% Independent Directors);

FAE : Percentage of financial or accounting expertise of directors divided by total board of director of firm *i* at time *t* (% Financial or Accounting Expertise of Directors in Audit Committee);

IC : A Dummy variable which a value of one if chairman of firm is the independence board and a value of zero otherwise, of firm *i* at time *t* (Independent Chairman) ;

CD : A Dummy variable which a value of one if there is not a spilt between chairman of firm and CEO and a value of zero otherwise, of firm *i* at time *t* (CEO Duality);

FD : Percentage of female directors of firm *i* at time *t* (% Female Directors)

FS : The natural logarithm of book value of total assets of firm *i* at time *t* (Firm Size)

$GEAR$: Total liabilities divided by total stockholder's equity of firm *i* at time *t* (Gearing Ratio)

SG : Total sales of the current year minus total sales of the previous year divided by total sale of previous year of firm *i* at time *t* (%Sale Growth)

ROA : Operating profit divided by average total assets of firm *i* at time *t* (Lagged Return on Assets)

ε_t : Residual at time t (Error Terms)

RESEARCH DESIGN

In this study, the causal or explanatory approach will be applied. A cross-sectional analysis will be conducted in this research. The sample size will be collected in Thailand SET 100 during year 2007-2009. Anyway the firms in the Banking, Insurance, Financing and Property Fund sector will not be included in this study because the transactions of those industries will be different to other industries. The data will be collected on December 29, 2009, total 80 firms, which have been shown in Appendix B. The secondary data is applied as source of data in this study. Appendix C shows the details of source of secondary data such as the SET, SEC, Website of listed firms, etc.

Focusing in measurement of variables for Regression model can explained as follows (Appendix D):

BS : Total board of director at time t (Board Size), will be calculated by counting the number of board of director shown in report 56-1 at the year ended under the title "board of director and management team"

ID : Percentage of total independence director at time t (% Independent Directors), will be calculated by counting the number of board of director and the number of independence director, shown in report 56-1 at the year ended under the title "board of director and management team"

According to SET regulation, independence director (or outside director) will have outstanding share in that firm not more than 0.05%. Also independence director must not be the management team, employee or advisors who have the fixed salary. Under SET regulation, the listed firm must have at least 3 independence directors.

$$ID = \frac{\text{Total independence director} \times 100}{\text{Total director}}$$

FAE : Percentage of financial or accounting expertise of directors in audit committee at time t (% Financial or Accounting Expertise of Directors in Audit Committee), will be calculated by counting the number of board of director and the number of financial or accounting expertise of directors in audit committee, shown in report 56-1 at the year ended under the title "board of director and management team". Under SET regulation, the financial or accounting expertise of directors in audit committee must have knowledge in financial or accounting field must have at least a bachelor degree in financial or accounting, or have experience in financial or accounting field.

$$FAE = \frac{\text{Financial or accounting expertise of directors in audit committee} \times 100}{\text{Total audit committee}}$$

IC : Dummy variable which a value of one if chairman of firm is independence board and a value of zero otherwise, at time t (Independent Chairman), will be calculated by checking whether chairman of directors is independence board, which shown in report 56-1 at the year ended under the title "board of director and management team".

CD : Dummy variable which a value of one if there is not a spilt between chairman of firm and CEO and a value of zero otherwise, of firm *i* at time *t* (CEO Duality), will be calculated by checking whether there is not a spilt between chairman of firm and CEO, which shown in report 56-1 at the year ended under the title "board of director and management team".

FD : Percentage of female directors at time t (% Female Directors), will be calculated by counting the number of board of director and the number of female directors, shown in report 56-1 at the year ended under the title "board of director and management team".

$$FD = \frac{\text{Percentage of female directors x 100}}{\text{Total directors}}$$

Q : According to theory of Tobin's Q, Lindenberg and Ross (1981) studied about the valuation, they stated that the firm valuation can measure with market value of stock. Chung and Pruitt (1994) defined to calculate Tobin's Q as market value of firm, they stated that Tobin's Q is measured as market value of common stock (market price of common stock multiply outstanding share volume) plus market value of preferred stock and market value of liabilities, also book value of assets will be used instead of replacement cost.

$$Q = \frac{(MP \times OSV) + MV_{p/s} + MV_l}{BV_a}$$

Where:

MP : Market Price of common stock

OSV : Outstanding Share Volume

$MV_{p/s}$: Market Value of Preferred Stock

MV_l : Market Value of Liabilities

BV_a : Book Value of Assets

DATA ANALYSIS

The statistic used in this study consists of descriptive statistics, which are Mean and Standard Deviation, Pearson's Product Moment Correlation Coefficient, Inferential Statistics with Multiple Regression Analysis, shown in Appendix E.

EMPIRICAL RESULTS

Table 1 presents descriptive statistics of the variables which average for 3 years. The results show that the mean for 3 years of Tobin's Q is 1.36, minimum is 0.34 and maximum is 7.20. Average total number of board size is 12, which the maximum is 18 whereas the minimum is 5. Average percentage of total independence director is 38, which shown the maximum 80 and the minimum is 18. When focus on percentage of financial or accounting expertise of directors in audit committee, it shows the average is 34. Also when concentrate on percentage of chairman of firm is independence board, the average shows 36.5. Whereas the descriptive statistic shows the average percentage is 9.6 when there is not a spilt between chairman of firm and CEO. About average of percentage of female directors is shown 10.4.

Focusing on control variables, the statistic shows that average ROA is 10.7, whereas the maximum is 55 percent and the minimum is minus 22 percent. Average market value of total assets is 54,839 million baht. The gearing ratio which is measured as total liabilities divided by total stockholder's equity and the average sales growth are 1.32 percent and 9.6 percent, respectively.

Table 1: Descriptive statistics, average for 3 years (2007-2009).

(N = 249)

Variables	Variable Description	Min	Max	Mean	Std. Dev.
Q	Tobin's Q	0.34	7.20	1.36	0.81
BS	Board Size (Number)	5	18	12	2.5
ID	% Independent Directors	18	80	38	12.5
FAE	% Financial or Accounting Expertise of Directors in Audit Committee	0	100	34	26.0
IC	% Independent Chairman	0	100	36.5	48.3
CD	% CEO Duality	0	100	9.6	29.6
FD	% Female Directors	0	38	10.4	9.7
ROA	% Lagged Return on Assets (2006-2008)	- 22	55	10.7	10.2
FSMB	Firm Size (Book Value of Total Assets) (million bath)	2,018	1,103,589	54,839	115,806
GEAR	Gearing Ratio	0	16.83	1.32	1.57
SG	% Sale Growth	-60	369	9.6	39.89

Appendix F presents descriptive statistics of the variable for each year during year 2007-2009. It shows the Tobin's Q is 1.61, 1.08 and 1.07 for year 2007-2009, respectively. Average number of board size for each year is 12 persons, the maximum of every year is 18, whereas the minimum of year 2008 and year 2009 is 6 person and the minimum of year 2007 is 5. The average percentage of independence director of year 2007, 2008 and 2009 are 36.7, 38.5 and 38.7 percent, respectively. The minimum of percentage of independence director in year 2007 is 19 percent and the maximum is 69 percent. Whereas the maximum

and the minimum of percentage of independence director in year 2008 and 2009 is equal, the minimum is 18 percent and the maximum is 73 percent.

Focusing on average percentage of financial or accounting expertise of directors in audit committee of year 2007, 2008 and 2009 are 35.6, 33.6 and 33.6, respectively. Whereas, the maximum and the minimum is 100 percent and zero percent is equal for all years. For average percentage of chairman of firm is independence board of year 2007, 2008 and 2009 are 33.8, 36.9 and 36.5, which the maximum and the minimum is 100 percent and zero percent, which is equal for all years. The descriptive statistic shows the average percentage of year 2007, 2008 and 2009 are 10.0, 9.5 and 9.3 when there is not a spilt between chairman of firm and CEO which the maximum and the minimum is 100 percent and zero percent, which is equal for all years. About average of percentage of female directors of year 2007, 2008 and 2009 are 10.7, 10.2 and 10.4, which the maximum and the minimum is 38 percent and zero percent, which is equal for all years.

Focusing on control variables, the statistic shows that average ROA of year 2006, 2007 and 2008 are 12.2, 11.9 and 9.6, whereas the maximum of year 2006, 2007 and 2008 are 38.0, 42.0 and 55.0, whereas the minimum of year 2006, 2007 and 2008 are -12, -3 and -22 percent. Average market value of total assets of year 2007, 2008 and 2009 are 51,216 million baht, 54,839 million baht and 53,262 million baht, whereas the maximum of year 2007, 2008 and 2009 are 891,524 million baht, 885,192 million baht and 1,103,589 million baht, respectively. The minimum of year 2007, 2008 and 2009 are 2,018 million baht, 2,935 million baht and 2,582 million baht, respectively. The average gearing ratio which is measured as total liabilities divided by total stockholder's equity of year 2007, 2008 and 2009 are 1.30, 1.39 and 1.38 percent, respectively. Whereas the maximum and the minimum of year 2008 and 2009 are equal, which are 16.83 and 11.10 percent. The maximum and the minimum of gearing ratio of year 2007 are 11.46 and 0.07. Finally, the control variable which is the percentage of sale growth, the average of year 2006, 2007 and 2008 are 13.17, 16.06 and 15.82. Whereas the maximum and the minimum of year 2008 and 2009 are equal, which are 369 and - 60 percent. The maximum and the minimum of average percentage of sale growth of year 2007 are 300 and - 36 percent.

Before testing for the Multiple Regression Analysis, we need to test correlation between all variables in order to check for auto-correlation, singularity and multicollinearity. Table 2 shows correlation coefficients for 3 years (year 2007- year 2009). It shows that there is no correlation among testing variables.

Table 2: Correlation Coefficients for 3 years (year 2007- 2009).

	Q	BS	ID	FAE	IC	CD	FD	ROA	FSMB	GEAR
BS	-0.099	1.000								
ID	-0.078	-0.175	1.000							
FAE	-0.002	-0.206	0.146	1.000						
IC	-0.116	-0.059	0.363	0.105	1.000					
CD	0.200	-0.151	-0.147	-0.037	-0.248	1.000				
FD	-0.099	-0.136	0.122	0.167	0.214	0.002	1.000			
ROA	0.598	-0.183	0.100	0.021	-0.044	0.104	-0.029	1.000		
FS	-0.033	0.273	0.281	-0.009	-0.121	-0.079	-0.028	-0.009	1.000	
GEAR	-0.093	0.203	-0.149	-0.024	-0.085	-0.084	-0.125	-0.232	0.086	1.000
SG	-0.007	-0.113	0.054	0.090	0.040	0.069	0.052	0.124	-0.040	0.023

Variables	Variable Description
Q	Tobin's Q
BS	Board Size
ID	% Independent Directors
FAE	% Financial or Accounting Expertise of Directors in Audit Committee
IC	Independent Chairman (%)
CD	CEO Duality (%)
FD	% Female Directors
ROA	Lagged Return on Assets (%)
FS	Firm Size (Book Value of Total Assets)
GEAR	Gearing Ratio
SG	% Sale Growth

Moreover, we test the error of data. The histogram figure indicates that the distribution is abnormal. The probability plot has deviation. Besides, this study uses Durbin-Watson Test for checking autocorrelation, the Durbin-Watson Test shows d = 1.743. It means there is degree of freedom among the variables. For testing regression standardized residual with regression standardized predicted value, the results states that there is no pattern on plots. Multicollinearity also is tested, all independence variables shows that all VIF is less than 5, it means board size, percentage of independent directors, percentage of financial or accounting expertise of directors in audit committee, percentage of independent chairman, CEO Duality (%) and percentage of female directors do not relate for each other.

Table 3 and table 4 shows the result of pooled - data Multiple Regression Analysis (R Square = 0.406), stated that independence variables have significant influence to dependence variable (p = 0.000, which is less than 0.05). In other word, board structure has an influence on a firm value.

Focusing on coefficient between dependence variable and independence variable, we find that CEO Duality and Lagged Return on Assets have significant (p = 0.014 and p = 0.000, which is less than 0.05, respectively), whereas, the other independence variables do not show the significant statistic and the incremental significant.

Results from the multiple regression shows that there are 3 variables consistent with H1, the coefficient on board Size (BS), percentage of financial or accounting expertise of directors in audit committee (FAE)) continue to be positive and significant (p < 0.05). Whereas, the hypothesis about CEO duality (CD), which there is not a spilt between chairman of firm and CEO, is not consistent with H1, it means that there is positively relation between Tobin's Q and CEO duality at level 0.05.

Furthermore, the Tobin's Q is negatively relation with percentage of independent directors (ID), independent chairman (IC) and percentage of female directors (FD), which these hypotheses will be rejected at level 0.05. Whereas, the Tobin's Q is positively relation with lagged return on assets (ROA) and Gearing Ratio (GEAR), which are control variables. The Tobin's Q is negatively relation with percentage of sale growth (SG) and Firm Size (FS).

However, the regression model with dependence variable and independence variables without including 4 control variables in the model indicates that one hypothesis is rejected (Hypothesis H1e), which means there is a positively relation between Tobin's Q and CEO Duality (CD). This findings suggests that CEO who is also acting as a chairman has the influential effect on the firm value.

Moreover, the result of regression model with 4 control variables indicates that two hypotheses are rejected. The two hypotheses are H1d and H1e. There is positively relation between Tobin's Q and CEO Duality (CD) but negatively relation between Tobin's Q and percentage of Independent Directors (ID).

According to the regression analysis for each year, the results of regression analysis of year 2007 and 2009 have a statistic significant at 0.05. The result of regression analysis of year 2007 and year 2009 shows the similar findings with pooled - data regression.

Table 3: Summary of Regression Results .

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	66.230	10	6.623	16.273	.000[a]
	Residual	96.866	238	.407		
	Total	163.096	248			

a) Predictors : (constant), BS, ID, FAE, IC, CD, FD, ROA, FS, GEAR, SG

Table 4: Regression Results for 3 year (year 2007- year 2009).

	Coefficient	t-statistic
Constant	1.816	2.004*
BS	0.011	0.180
ID	-0.092	-1.593
FAE	0.024	0.463
IC	-0.005	-0.089
CD	0.132	2.486*
FD	-0.072	-1.353
ROA	0.603	11.224*
FS	-0.048	-0.812
GEAR	0.044	0.822
SG	-0.088	-1.724
R^2 = 0.406		

*Significant level .05

IMPLICATION TO RESEARCH RESULTS

For Pooled-Data result, R Square is equal to 0.406. Considering this result with our hypotheses, the findings, using F-test, suggest that there is statistical significant difference. However, if we consider the coefficient parameters of each variable, the results show that only one selected variable, CEO Duality, has the effect to the value of a company (*p*-value = .014). Using t-test, findings show there is negatively statistical significant different. The outcome suggests that the CEO who is also acting as a chairman of a company can influence the way the firm is run. The objective of a company would also be fulfilling if the two positions are held by the same person. This finding is similar with Anderson and Anthony (1986). The result also indicate the larger the company, the more benefit and lose if a company has the leader that held two position as CEO and chairman (Brickley et al. 1997). In conclusion, the reverse relationship between CEO Duality and Firm value happen and no statistical significance for these other variables.

The results shows that there is no statistical significant in board size, Mak and Kusnadi (2005) also supported the idea that more board of directors will not increase financial performance. Their findings stated that co-operation will be problematical if there is more board of directors. They also argue that it is not guarantee that more board of directors will generate financial performance.

For the percent of independent directors and percentage of financial or accounting expertise of directors in audit committee, the board member with freedom to make any decisions without involving self interested may not reflect the higher revenue than those

that have less independent directors. One explanation of this outcome is the degree of freedom that independent director have in making decisions. For the number of independent directors, the right amount depends on the work or expertise that the firm may request from these directors. Moreover, the agency theory also suggests that the independent directors should not hold more than 0.05 percent of stock. That said, this group of directors might not contribute to the price of a company stock. Bhagat and Black (2002) also concluded that a firm that has independent directors may not have anything to do with a company stock price.

The results shows that the independence chairman is no statistical significant. Donaldson and Davis (1991) also supported the idea that independent director who serves as CEO is more likely to help increase the productivity of a company. There is also no statistical significant between male and female director. Williams and O'Reilly (1998) suggested that to have directors from both sex would not allow better communication and will increase the emotional judgment. Lau and Murnighan (1998) argued that the higher the numbers of different sex in the board the higher the possibility of having the longer discussion and time need to make decision.

CONCLUSION

The findings of this study suggest that structure of board of director has a direct effect on the value of a firm. The result suggests that CEO duality has a incremental significant. Nevertheless, we can conclude that CEO Duality has positive relationship with the value of a firm while other variables have no influence to the firm's value. However, the regulator that is responsible for set up the rule and regulation should apply the board structure concept. The results of this project can enhance the company performance. The future research should focus on the relationship among other independent variables, and concentrate more on how the structure of a board of director is form and the method to measure firm value.

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Appendix A

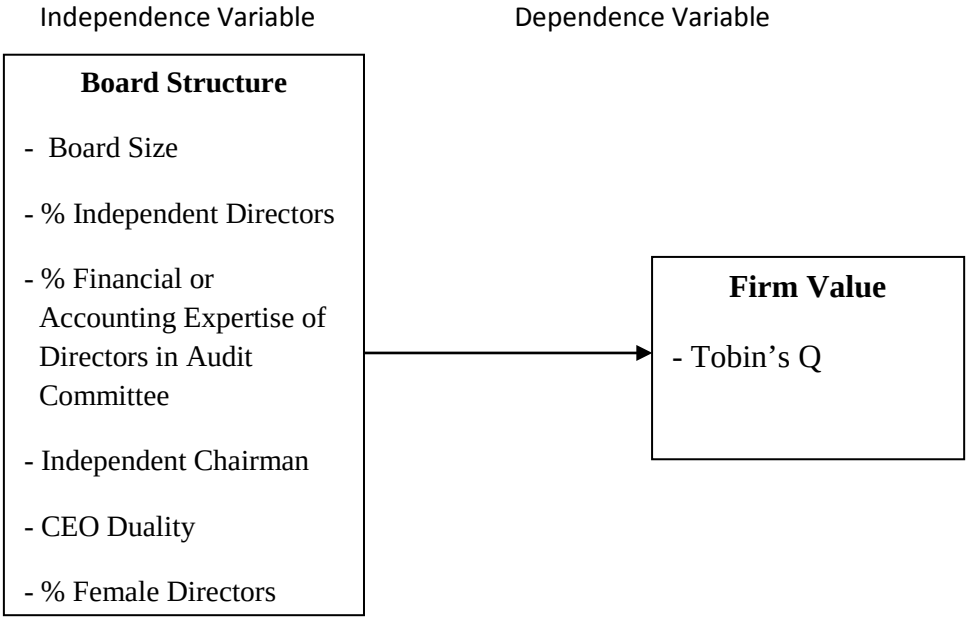

Figure 1 : Conceptual framework.

Appendix B

Classified Listed Company accordance to the sector in SET 100, as of December 29,2007

Sector	No. of Company
Agriculture	2
Automotive	1
Construction Materials	9
Commerce	6
Electronics	4
Energy and Utility	14
Food and Beverage	5
Health Care Services	3
Home & Office Products	1
Industrial Materials & Machinery	3
Information Communication and Technology	7
Media & Publishing	3
Mining	1
Packaging	0
Petrochemical	2
Property	17
Tourism & Leisure	1
Transportation & Logistics	8
Total	**87**

Appendix C

Dependence Variable and Independence Variable

Type of Variable	Variable	Symbol	Measurement	Source of data
Independence Variable	Board Structure	BS	Ratio Scale	Form 56-1 , Annual report (SEC)
		ID	Ratio Scale	Form 56-1 , Annual report (SEC)
		FAE	Ratio Scale	Form 56-1 , Annual report (SEC)
		IC	Nominal Scale	Form 56-1 , Annual report (SEC)
		CD	Nominal Scale	Form 56-1 , Annual report (SEC)
		FD	Ratio Scale	Form 56-1 , Annual report (SEC)
Dependence Variable	Firm Value	Tobin's Q	Ratio Scale	Form 56-1 , Annual report (SEC),SETSMART

Appendix D

Statistic Test

No.	Hypotheses	Statistic	
		Correlation Coefficient	**Multiple Regression Analysis**
Hypothesis 1	The Tobin's Q of firm listed in SET 100 is positively associated with Board size.	✓	✓
Hypothesis 2	The Tobin's Q of firm listed in SET 100 is positively associated with Percentage of Independent Directors.	✓	✓
Hypothesis 3	The Tobin's Q of firm listed in SET 100 is positively associated with Percentage of Financial or Accounting Expertise of Directors in Audit Committee.	✓	✓
Hypothesis 4	The Tobin's Q of firm listed in SET 100 is positively associated with Independent Chairman.	✓	✓
Hypothesis 5	The Tobin's Q of firm listed in SET 100 is negative associated with CEO Duality.	✓	✓
Hypothesis 6	The Tobin's Q of firm listed in SET 100 is positively associated with Percentage of Female Directors.	✓	✓

Appendix E
Details of source of secondary data

Source of secondary data	Type of source of secondary data	Type of data
SEC, SET	• Report of 56-1 year 2007-2009 • Financial statement year 2007-2009	• Book value of preferred stock • Additional paid in capital – preferred stock • Stockholder's equity • Outstanding common stock volume • Total liabilities • Total assets • Total revenue • Operating profit • No. of outstanding common stock as of the year ended , year 2007-2009
SEC, SET	• Report of 56-1 year 2007-2009 • Annual report year 2007-2009	• Percentage of independence director • Percentage of financial or accounting expertise of directors in audit committee • Percentage of female directors • Total independence director • Total board of director • No. Audit committee • No. Female directors • No. of financial or accounting expertise of directors in audit committee • Details of chairman • Details of CEO
SET	SET SMART	• Stock price of common stock at the year ended during year 2007-2009

Appendix F

Descriptive statistics for each year, during year 2007 - 2009

(N_{07} = 80, N_{08} = 84, N_{09} = 86)

Variables	Variable Description	Min	Max	Mean	Std. Dev.
Q_{07}	Tobin's Q – Year 2007	0. 43	7.20	1.61	0.92
Q_{08}	Tobin's Q – Year 2008	0.34	4.73	1.08	0.60
Q_{09}	Tobin's Q – Year 2009	0.34	4.73	1.07	0.60
BS_{07}	Board Size – Year 2007 (Number)	5	18	12	2.5
BS_{08}	Board Size – Year 2008 (Number)	6	18	12	2.5
BS_{09}	Board Size – Year 2009 (Number)	6	18	12	2.5
ID_{07}	Independent Directors – Year 2007 (%)	19.0	69.0	36.7	12.4
ID_{08}	Independent Directors – Year 2008 (%)	18.0	73.0	38.5	12.7
ID_{09}	Independent Directors – Year 2009 (%)	18.0	73.0	38.7	12.8
FAE_{07}	Financial or Accounting Expertise of Directors in Audit Committee – Year 2007 (%)	0	100	35.6	27.4
FAE_{08}	Financial or Accounting Expertise of Directors in Audit Committee – Year 2008 (%)	0	100	33.6	25.9
FAE_{09}	Financial or Accounting Expertise of Directors in Audit Committee – Year 2009 (%)	0	100	33.6	25.8
IC_{07}	Independent Chairman – Year 2007 (%)	0	100	33.8	47.6
IC_{08}	Independent Chairman – Year 2008 (%)	0	100	36.9	48.5
IC_{09}	Independent Chairman – Year 2009 (%)	0	100	36.5	48.4
CD_{07}	CEO Duality – Year 2007 (%)	0	100	10.0	30.2
CD_{08}	CEO Duality – Year 2008 (%)	0	100	9.5	29.5
CD_{09}	CEO Duality – Year 2009 (%)	0	100	9.3	29.2
FD_{07}	Female Directors – Year 2007 (%)	0	38.0	10.7	10.1
FD_{08}	Female Directors – Year 2008 (%)	0	38.0	10.2	9.5
FD_{09}	Female Directors – Year 2009 (%)	0	38.0	10.4	9.8
ROA_{06}	Lagged Return on Assets – Year 2006 (%)	-12.0	38.0	12.2	9.0
ROA_{07}	Lagged Return on Assets – Year 2007 (%)	-3.0	42.0	11.9	7.7
ROA_{08}	Lagged Return on Assets – Year 2008 (%)	-22.0	55.0	9.6	11.6
$FSMB_{07}$	Firm Size (Book Value of Total Assets) – Year 2007 (million bath)	2,018	891,524	51,216	109,237
$FSMB_{08}$	Firm Size (Book Value of Total Assets) – Year 2008 (million bath)	2,94..	885,....	54,.....	107,56..
$FSMB_{09}$	Firm Size (Book Value of Total Assets) – Year 2009 (million bath)	2,935	885,192	53,262	106,416
$GEAR_{07}$	Gearing Ratio – Year 2007	0.07	11.46	1.30	1.51
$GEAR_{08}$	Gearing Ratio – Year 2008	0.11	16.83	1.39	1.89
$GEAR_{09}$	Gearing Ratio – Year 2009	0.11	16.83	1.38	1.87

SG_{07} SG_{08} SG_{09}	Sale Growth – Year 2007 (%) Sale Growth – Year 2008 (%) Sale Growth – Year 2009 (%)	-36.0 -60.0 -60.0	300.0 369.0 369.0	13.17 16.06 15.82	38.93 49.93 49.37

IT GOVERNANCE TRANSITION ANALYSIS FROM ITIL TO COBIT: CASE STUDY BANKING INDUSTRY IN THAILAND

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ABSTRACT

The purpose of this study is to identify the key difference among two well-known IT governance standards: Information Technology Infrastructure Library (ITIL) and Control Objectives for Information and Related Technology (COBIT). The setting of this study is the information technology systems in Financial Institutions of Thailand where many institutions have been applied ITIL as their IT risk management but considering COBIT implementation. The results provide a guideline for moving from ITIL to COBIT.

Keywords: Information Technology Risk Management, COBIT, ITIL, IT best practice.

INTRODUCTION

During 1997 and 1998, Thai financial crisis was the most severe in Thai economy. The Thai Baht currency had been weakened by several attacks from international funds. Finally, the Thai Government at that time was forced to float the currency. The Baht immediately dropped significantly in value, losing 20 percent in one month, and falling to less than half its former value within six months.

Due to the financial crisis during 1997-1998, Bank of Thailand (BOT) enforced the financial institute implement an international risk management framework such as BASEL I. Basel I was published by the Basel Committee (BCBS) in Basel, Switzerland in 1988. It was the results from the round of deliberations by central bank representatives from around the world. BASEL I only focused on a credit risk problem by setting minimal capital requirements for financial institutes. Later, BASEL II was developed in 2004 as a guideline for broader financial and operational risk management for financial institutes (Hamaker, 2004; Reghavan, 2006). At time of developing this article, all of Thailand financial institutes are on the process of implementing BASEL II.

Even though, the financial risk management primarily focuses on the financial operations like loan, credit and debt issues. The raising of applications in Information Technology (IT) as part of supporting tool in back-office operations and new customer outreach operation for the front office (Boritz, 2005; Klamm and Watson, 2009). The availability and reliability of the IT system has become a critical to the entire operations of the major Thailand banks. Therefore, the effort in implementing risk management, such as BASEL II, has included the issues of IT risk management into it. At that time, an Information Technology Infrastructure Library (ITIL) which

are developed and promoted by the United Kingdom's Office of Government Commerce (OGC) in 1989 for its first version, has been popular among the international firms in developed countries. Following the recognized IT risk management framework, it is the quickest way for Thailand banks to ensure the confidence of both Thailand central bank and foreign rating agencies in part of the corporate good governance campaign after the financial crisis. As a result, ITIL has been widely adopted in Thailand financial institutes.

With a rapidly developed and changes in Information technology including the popularity of using information technology in daily life of the ordinary people, in U.S., 95 million U.S. households use the Internet; 72.5 million of those households participate in online banking, with 36.4 million using online bill pay, it was a 51 percent increase in Internet usage per household since 2000, and an even more increase of 84 percent in online banking and 78 percent in online bill payment. Many Thailand banks has been aggressively rolled out many services related with information technology throughout the country, such as an Automatic Teller Machine (ATM), telephone Banking, Internet Banking, mobile Banking, e-billing and e-payment etc. The trend of using computer system to scan customer profiles & transactions to match with new financial products is very popular and very demanding in computing capability. In addition, many banks in Thailand now operate seven days a week in shopping center or community center.

As a result, most of Thailand financial institutes have increased in their IT resource capability and capacity (Hardware, Software, and People) to provide an adequate service level for both of their front and back office operations. With many new IT initiatives as new financial products or services, project management and system evaluating and monitoring have become critical to determine the success of overall initiative. According to ISACA (2008), ITIL is a best practice but at the implementation level, ITIL often lacks of the detail on how to operate a certain practice. Since the IT systems and their complexity grew larger and larger in recent years, IT department has been look for more detail standard. The Control Objectives for Information and related Technology (COBIT) is considered by many Thailand banks as more detail alternative of ITIL. The scope of COBIT framework is more widely than ITIL process as show in Figure 1.

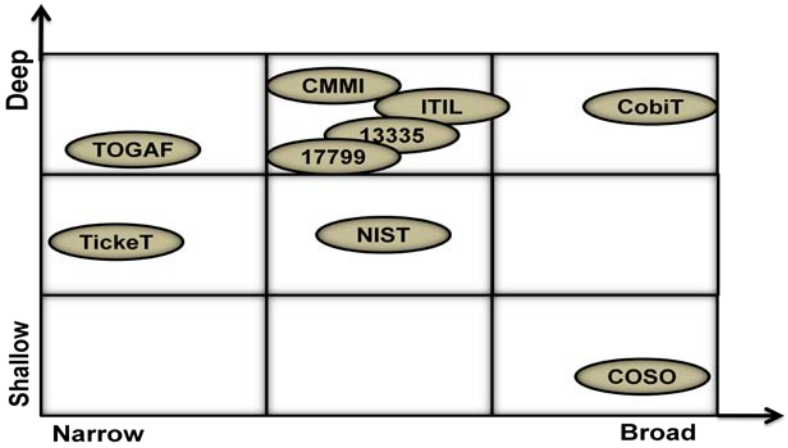

Figure 1: IT Standard Address adopted from www.itgi.org.

Control Objectives for Information and related Technology (COBIT) is developed and released by the Information Technology Governance Institute (ITGI) as an IT process and control framework linking IT to business requirements. With the addition of management guidelines in 1998, COBIT is often referred as a management framework or IT governance framework, providing management tools, such as metrics and maturity models, to complement the control framework. COBIT gives managers, auditors, and IT users with a set of measures, indicators, processes and best practices, to assist them in maximizing the benefits of their information technology systems/projects/initiatives (Hardy, 2006). The current version is COBIT 4.1.

Since, many banks have implemented ITIL. Moving to another framework like COBIT can be confusing and time consuming transition. However, both ITIL and COBIT are considered as a good and comprehensive framework. Therefore, the purpose of this research is to identify the areas of ITIL and COBIT which are similar which will required less effort in transition. And, identify the areas that need an effort including new activities, documents etc. in the transition from ITIL(version 3) to COBIT(version 4.1). Moreover, this research also check if there is an area where COBIT missed and but exists in ITIL. The benefits of this research are to reduce time in transition and to provide guideline about where IT department need to put an effort to ensure the success of obtaining COBIT certificate.

BACKGROUND

Information Technology Infrastructure Library (ITIL)

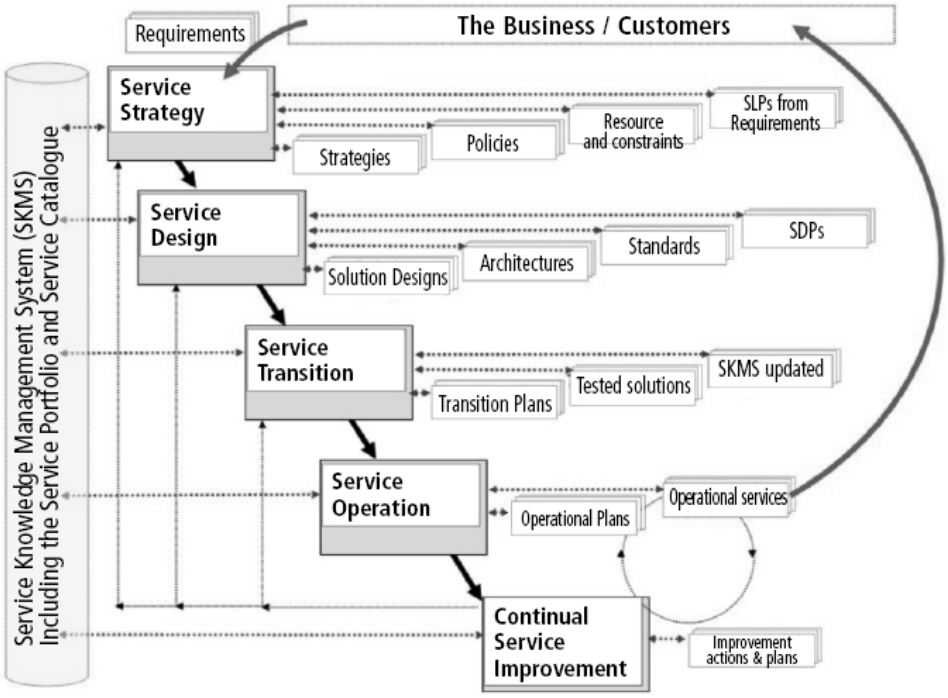

Figure 2: ITILv3 IT service lifecycle stages.

ITIL was developed by the effort of Her Majesty's Stationery Office (HMSO), United Kingdom on behalf of the Central Communications and Telecommunications Agency (CCTA) to provide a public framework and best practice for managing IT services and their environment. From its first published in 1989, ITIL has known as a comprehensive IT management best practice. The latest version is ITIL v3 which released in May 2007 (Cannon and Wheeldon, 2007; Iqbal and Nieves, 2007; Shirley and Macfarlane, 2007; Vernon and Rudd, 2007). ITIL v3 consists of five building blocks in IT system life cycles: 1) Service strategy 2) Service design 3) Service transition 4) Service operations and 5) Continual service improvement as shown in Figure 2.

In general, the development of IT system starts from the change in requirements of the business. The service strategies of IT system are formulated and aligned to meet business requirements within a service level package (SLP) to achieve a defined set of business outcomes. Then, the IT service design begins by involving with system architectures, solutions and standards in order to produce IT solution with a service design package (SDP). In service transition stage, the IT service is evaluated, tested and validated while relevance details are updated into the service knowledge management system (SKMS). When IT service is ready to be used (live environment), it enters the service operation stage. In addition, the search for continual service improvement is the key to overall system success by identifying the weaknesses or failures within any of IT life cycle stages.

Control Objectives for Information and related Technology (COBIT)

A control objectives for information and related technology (COBIT) is an IT governance framework which developed by the Information Systems Audit and Control Association (ISACA) in 1996. Later, ISACA set up the IT Governance Institute (ITGI) as a principle to promote, research, and develop the IT governance best practices and standards including the later version of COBIT. Currently, ISACA has planned to issue COBIT version 5 in 2011. However, the research conduct in this article has been worked under the framework of COBIT version 4.1 (IT Governance Institute, 2005).

In general, COBIT is a business-focused IT framework that guides organization management team by closing the gap among control requirements, technical issues, business risks, and stakeholder communications. With COBIT, the company executives can develop coordinated policies in both IT and business perspectives throughout the organization. The COBIT conceptual framework and principles begin with business requirements. With essential information provided by organization IT systems, the enterprise can utilize the received information to achieve its objectives and goals. Therefore, the enterprise needs to provide enough IT resources. Then, IT resources must be managed and monitored based on a structured set of processes in order to deliver the required enterprise information. The COBIT processes help ensure alignment between IT operations and business requirements. The fundamental concept of COBIT is illustrated in Figure 3.

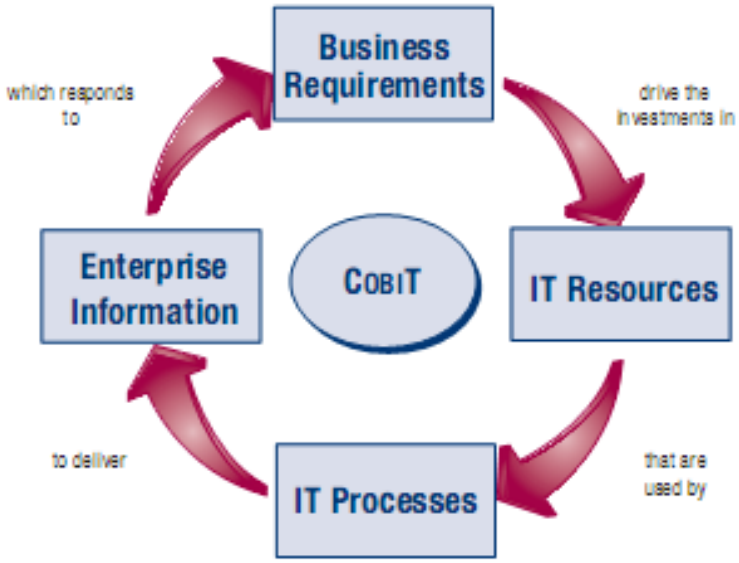

Figure 3: COBIT fundamental concept.

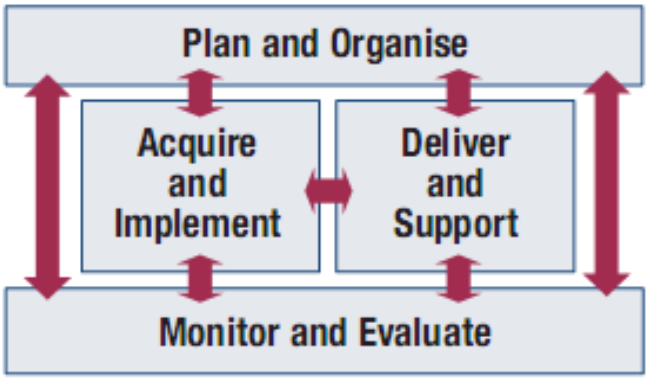

Figure 4: Four inter-related COBIT process groups.

COBIT classifies its generic processes and activities into four main groups: 1) Plan and Organize, 2) Acquire and Implement, 3) Deliver and Support and 4) Monitor and Evaluate as shown in Figure 4. These four main COBIT process groups are mapped and aligned with traditional IT development concept of plan, build, run and monitor. In Plan and Organize (PO) process group, it provides direction to solution delivery. In Acquire and Implement (AI) process group, it provides the solutions and hands them over to be turned into services. In Deliver and Support (DS) process group, it receives the solutions from AI process group and makes them available for end users. In Monitor and Evaluate (ME) process group, it monitors all processes to ensure that the direction provided is followed and IT operations still aligned in respond to the business objectives and goals.

The COBIT framework provides a reference process model and common language for everyone in organization to view and manage IT activities. Incorporating an operational model and a common language for all parts of the business involved in IT is and initial steps toward IT good governance. It also provides a framework for measuring and monitoring IT performance, communicating with service providers and integrating best management practices (Von Solms, 2005).

METHOD

In this research, COBIT's 34 processes are mapped with the ITIL v3 processes descriptions. By analyzing the detail description of ITIL v3 processes in comparison with individual process of the COBIT's 34 processes, the similarity of process scope and activities are identified using numeric rating scale shown in Table 1.

Table 1: Rating of the similarity of requirements between COBIT 4.1 and ITIL v3.

Rating	Description
1.0	All/almost of requirements of the control objective are covered the guidance in ITIL v3
0.8	Many aspects of the control objective are addressed by ITIL v3, but the key activity areas are not covered completely.
0.6	Some aspects of the control objective are addressed by ITIL v3, but the key activity areas of the control objective are more than 50% but not greater than 80%
0.4	Some aspects of the control objective are addressed by ITIL v3, but the key activity areas of the control objective are not greater than 50%
0.2	A few aspects of the control objective are addressed by ITIL v3.
0	There is no match between the requirements of COBIT and ITIL v3.

RESULTS

Due to the limited pages, the comparison between ITIL and COBIT by linking the activity stated in ITIL v3 to COBIT 4.1 is shown only the activity in the PO process group in Table 2.

Table 2: Result of linked activity areas between ITIL and COBIT

COBIT		Link	Similarity Rating between ITIL and COBIT
Group	**Process**	**Activity Area**	
PO 1.0	Define a Strategic IT Plan	IT strategic planning is required to manage and direct all IT resources in line with the business strategy and priorities. The IT function and business stakeholders are responsible for ensuring that optimal value is realized from project and service portfolios. The strategic plan improves key stakeholders' understanding of IT opportunities and limitations, assesses current performance, identifies capacity and human resource requirements, and clarifies the level of investment required. The business strategy and priorities are to be reflected in portfolios and executed by the IT tactical plan(s), which specifies concise objectives, action plans and tasks that are understood and accepted by both business and IT.	0.8
PO 2.0	Define the Information Architecture	The information systems function creates and regularly updates a business information model and defines the appropriate systems to optimize the use of this information. This encompasses the development of a corporate data dictionary with the organization's data syntax rules, data classification scheme and security levels. This process improves the quality of management decision making by making sure that reliable and secure information is provided, and it enables rationalizing information systems resources to appropriately match business strategies. This IT process is also needed to increase accountability for the integrity and security of data and to enhance the effectiveness and control of sharing information across applications and entities.	0.2

COBIT		Link	Similarity Rating between ITIL and COBIT
Group	**Process**	**Activity Area**	
PO 3.0	Determine technical Direction	The information services function determines the technology direction to support the business. This requires the creation of a technological infrastructure plan and an architecture board that sets and manages clear and realistic expectations of what technology can offer in terms of products, services and delivery mechanisms. The plan is regularly updated and encompasses aspects such as systems architecture, technological direction, acquisition plans, standards, migration strategies and contingency. This enables timely responses to changes in the competitive environment, economies of scale for information systems staffing and investments, as well as improved interoperability of platforms and applications.	PO 3.0
PO 4.0	Define the IT Processes, Organization and Relationships	An IT organization is defined by considering requirements for staff, skills, functions, accountability, authority, roles and responsibilities, and supervision. This organization is embedded into an IT process framework that ensures transparency and control as well as the involvement of senior executives and business management. A strategy committee ensures board oversight of IT, and one or more steering committees in which business and IT participate determine the prioritization of IT resources in line with business needs. Processes, administrative policies and procedures are in place for all functions, with specific attention to control, quality assurance, risk management, information security, data and systems ownership, and segregation of duties. To ensure timely support of business requirements, IT is to be involved in relevant decision processes.	0.8
PO 5.0	Manage the IT Investment	A framework is established and maintained to manage IT-enabled investment programs and that encompasses cost, benefits, prioritization within budget, a formal budgeting process and management against the budget. Stakeholders are consulted to identify and control the total costs and benefits within the context of the IT strategic and tactical plans, and initiate corrective action where needed. The process fosters partnership between	0.8

COBIT		Link	Similarity Rating between ITIL and COBIT
Group	**Process**	**Activity Area**	
		IT and business stakeholders; enables the effective and efficient use of IT resources; and provides transparency and accountability into the total cost of ownership (TCO), the realization of business benefits and the ROI of IT-enabled investments.	
PO 6.0	Communicate Management Aims and Direction	Management develops an enterprise IT control framework and defines and communicates policies. An ongoing communication program is implemented to articulate the mission, service objectives, policies and procedures, etc., approved and supported by management. The communication supports achievement of IT objectives and ensures awareness and understanding of business and IT risks, objectives and direction. The process ensures compliance with relevant laws and regulations.	0.2
PO 7.0	Manage IT Human Resources	A competent workforce is acquired and maintained for the creation and delivery of IT services to the business. This is achieved by following defined and agreed upon practices supporting recruiting, training, evaluating performance, promoting and terminating. This process is critical, as people are important sets, and governance and the internal control environment are heavily dependent on the motivation and competence of personnel.	0.2
PO 8.0	Manage Quality	A quality management system (QMS) is developed and maintained that includes proven development and acquisition processes and standards. This is enabled by planning, implementing and maintaining the QMS by providing clear quality requirements, procedures and policies. Quality requirements are stated and communicated in quantifiable and achievable indicators. Continuous improvement is achieved by ongoing monitoring, analysis and acting upon deviations, and communicating results to stakeholders. Quality management is essential to ensure that IT is delivering value to the business, continuous improvement and transparency for stakeholders.	0.6

COBIT		Link	Similarity Rating between ITIL and COBIT
Group	**Process**	**Activity Area**	
PO 9.0	Access and Manage IT Risks	A risk management framework is created and maintained. The framework documents a common and agreed-upon level of IT risks, mitigation strategies and residual risks. Any potential impact on the goals of the organization caused by an unplanned event is identified, analyzed and assessed. Risk mitigation strategies are adopted to minimize residual risk to an accepted level. The result of the assessment is understandable to the stakeholders and expressed in financial terms, to enable stakeholders to align risk to an acceptable level of tolerance.	0.6
PO 10.0	Manage Projects	A program and project management framework for the management of all IT projects is established. The framework ensures the correct prioritization and co-ordination of all projects. The framework includes a master plan, assignment of resources, definition of deliverables, approval by users, a phased approach to delivery, QA, a formal test plan, and testing and post-implementation review after installation to ensure project risk management and value delivery to the business. This approach reduces the risk of unexpected costs and project cancellations, improves communications to and involvement of business and end users, ensures the value and quality of project deliverables, and maximizes their contribution to IT-enabled investment programs.	0.2

CONCLUSION

Based on the comparison between ITIL and COBIT as stated in Table 2, the overall similarity between ITIL and COBIT can be summarized based on COBIT process group as shown in Figure 5-8.

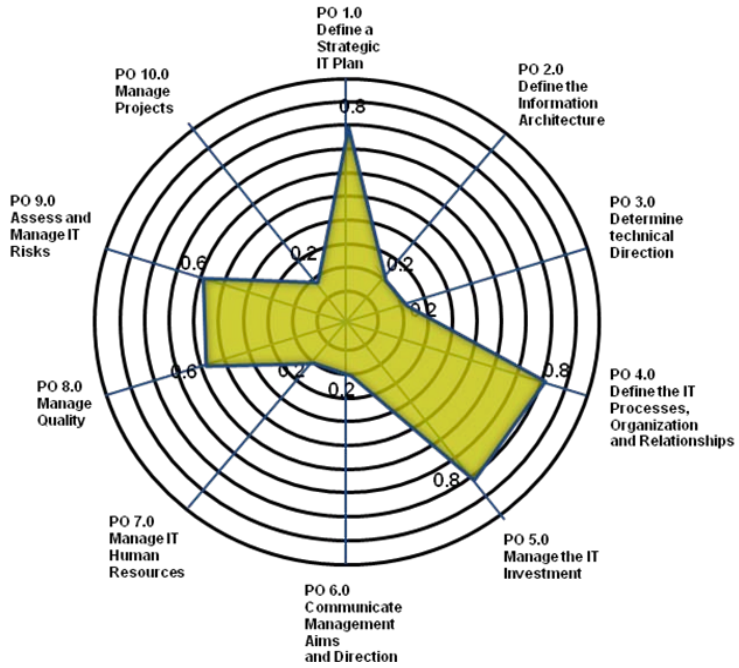

Figure 5: A similarity comparison between ITIL v3 and COBIT 4.1 process group PO.

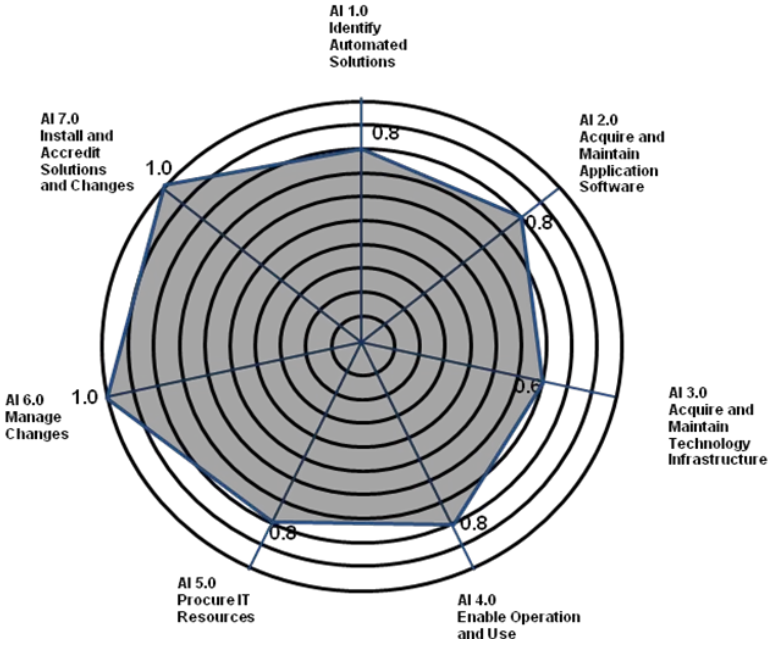

Figure 6: A similarity comparison between ITIL v3 and COBIT 4.1 process group AI.

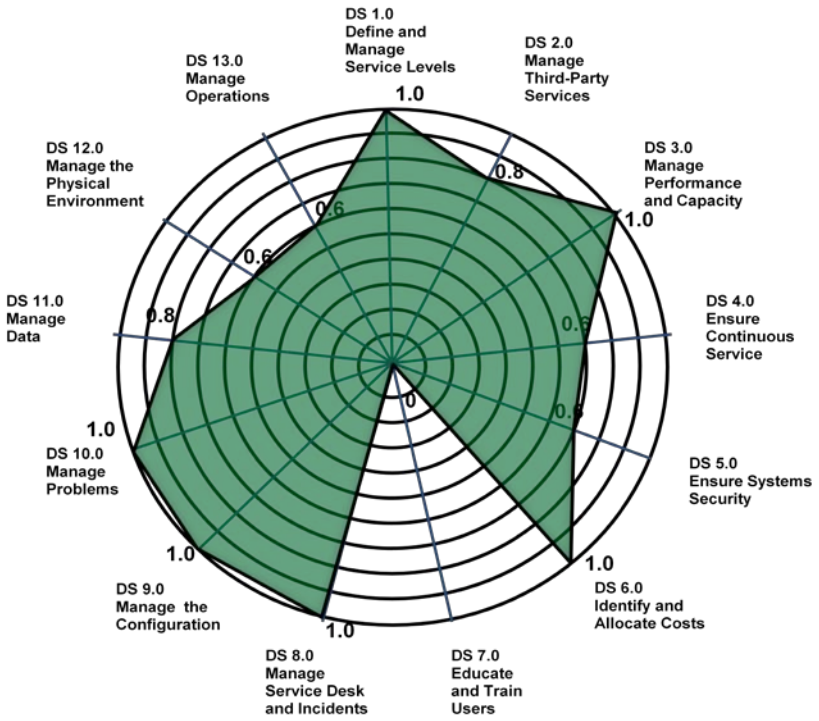

Figure 7: A similarity comparison between ITIL v3 and COBIT 4.1 process group DS.

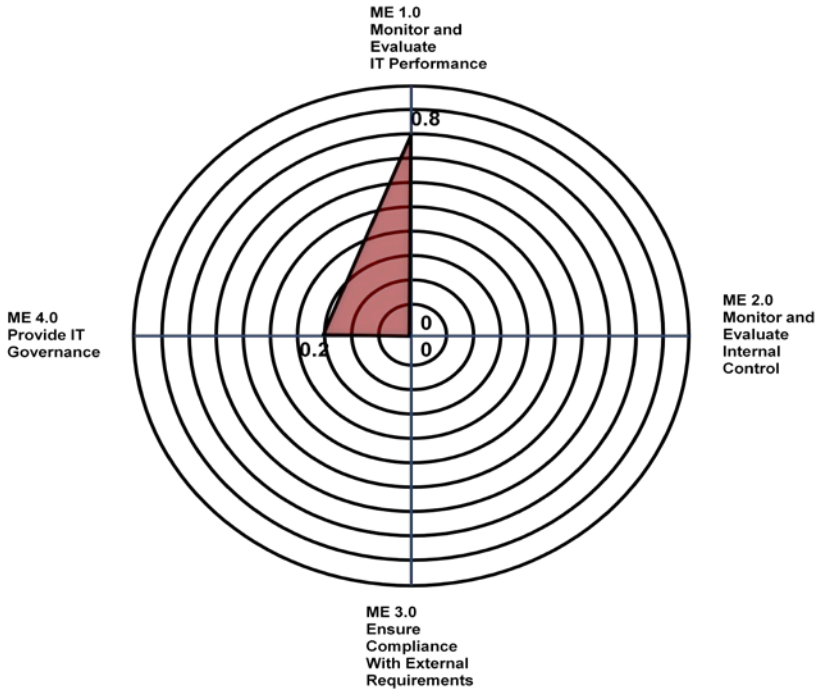

Figure 8: A similarity comparison between ITIL v3 and COBIT 4.1 process group ME.

Based on Figure 5-8, ITIL processes can be considered as similar processes to COBIT in AI and DS. However in Planning (PO) and Monitoring (ME) processes, COBIT has broader processes perspectives than ITIL. In addition, based on the results, when comparing COBIT and ITIL processes with the information system development life cycle (Strategy-Requirements-Design-

Develop-Test-Deploy-Operate-Monitor-Optimize), ITIL less focuses (lighter color) on monitoring and optimizing phase in compare to COBIT as shown in Figure 9.

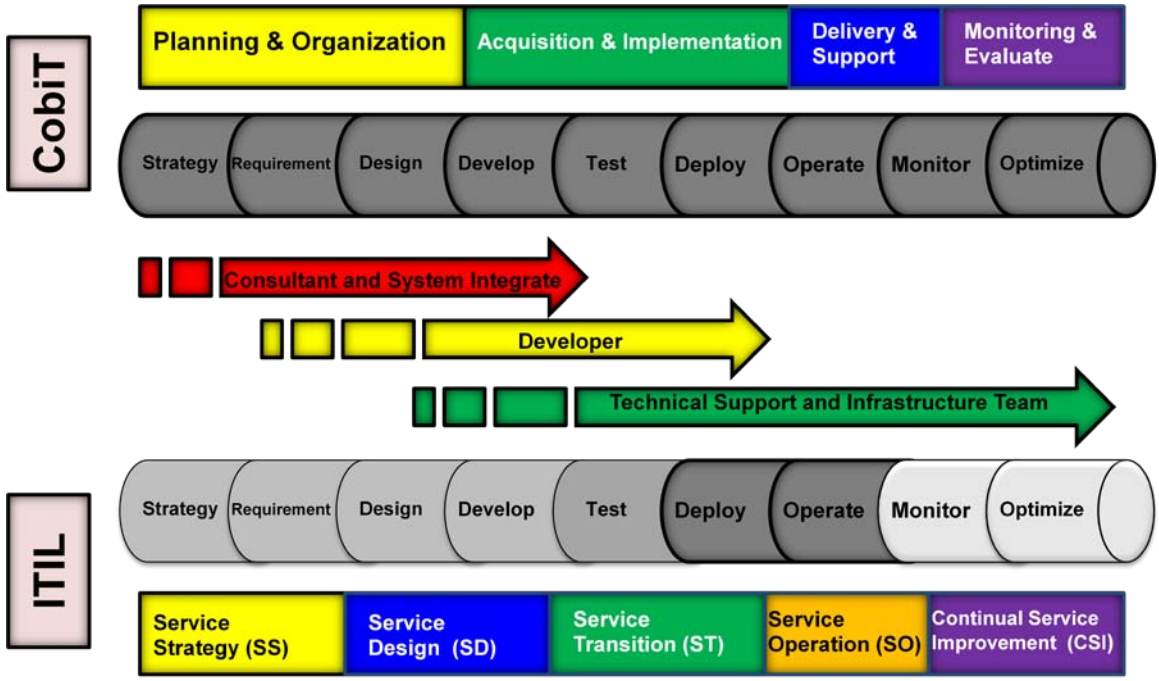

Figure 9: Comparing IT project development life cycle with COBIT and ITIL.

In conclusion, this research did not intend to compare the performance between COBIT and ITIL. It intended to identify the similarity and difference in case if there is a change in organization policy regarding IT governance standard in this case, Thailand banking industry.

If Thailand Banks has considered moving from ITIL to COBIT, the area they need to focus is the monitoring and evaluating processes. Several new procedures have to be developed and deployed. Moreover, the connection between IT strategy and organization strategy are needed to be identified and realigned including work procedures that enable theses connections.

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